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GEOLOGY OF THE BARENTS SEA

M. V. Klenova

Naval Oceanographic Office
Washington, D. C.

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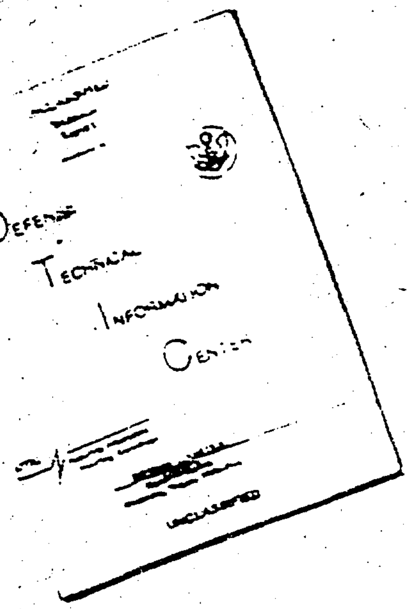

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GEOLOGIIA BARENTSOVA MORYA

(Geology of the Barents Sea)

by

M. V. Klenova

AKADEMIIA NAUK SSSR

(Academy of Sciences USSR)

MOSCOW 1960

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Chapter II

RELIEF OF THE BARENTS SEA FLOOR

According to origin and geological history, the seas of the earth are divided into epicontinental or platform seas and geosynclinal seas. These two types include, to a larger or smaller degree, all of the marine basins that are known to us (M. V. Klenova, 1934, 1948).

D. G. Panov (1939, 1943) suggested distinguishing a group of depression seas which were formed on the submerged slopes of ancient land masses as the folds sagged to great depths. Exempli gratia, he included in this group the Bering and Baltic Seas. We do not see a great need for such a division. Based on the character of bottom and geological history, these basins do not differ from other platform seas but at the present time, due to extremely narrow contacts with the ocean, they bear a peculiar character.

Also the geosynclinal type of seas consists of separate groups differing in smaller or greater degree of separation from the World Ocean.

In the process of their geological development, the separate portions of platform seas, as well as the entire geosynclinal basins, pass through stages of more or less complete union with the ocean, whereby the circulation of ocean waters affects all of the processes occurring in the sea.

The primary classification by geological origin and further division by the character of connection with the ocean and oceanic circulation enables us to include all of the marine basins existing on the earth with their most essential characteristics into two genetic series (table 1).

Investigations in marine geology demonstrate that, with the accumulation of our knowledge, the individual sections of floors of contemporary seas are of different origin, embracing the platform as well as the geosynclinal structures of land. Thus for instance, in its present boundaries the Caspian Sea floor consists of a platform in the north, of ancient foldings in the Mangyshlak area, of foot hills of the Caucasian Geosynclinal Zone and a portion of the Krasnovodsk platform farther to the south (of Mangyshlak), and of a deep depression caused by the geosynclinal regime of the Caucasian and Kopet-Dagh Mountain formations in the south. The Okhotsk Sea floor presents a platform in its northern part and a typical geosyncline in its southern part. The number of such examples increases as we acquire more knowledge of the character of relief and geological structure of the sea floor.

Therefore it may be more correct to talk of types of development of sea basins - namely, the platform and geosynclinal types - instead of types of sea basins, whereby the development of individual parts of one and the same sea basin may follow one or the other pattern.

Table 1

TYPES OF SEA BASINS

Type of sea	Seas having a free contact with the ocean	Seas whose contact with the ocean is restricted.*
Platform	Barents Sea	White Sea
	Kara Sea	Baltic Sea
	Laptev Sea	Hudson Strait
	East Siberian Sea	Red Sea (?)**
	Chukchi Sea	Azov Sea
	Yellow Sea	
	North Sea	
	Baffin Bay	
	Gulf of Guinea	
	Arabian Sea	
	Gulf of Bengal	
Geosynclinal	Bering Sea	Sea of Japan
	Caribbean Sea	Okhotsk Sea
	Gulf of Mexico	East China Sea
	Gulf of California	South China Sea
		Seas of Malayan Archipelago
		Persian Gulf
		Mediterranean Sea
		Sea of Marmara
		Black Sea

*On the basis of isolation from the World Ocean, the Caspian and Aral seas appear to be the extreme cases; their origin is associated with the development of a geosynclinal region in the southern USSR.

**The Red Sea has a rather peculiar character because it fills a relatively narrow and deep graben between two platform horsts.

The existing data as to the geological structure of the sea floor are far from satisfactory for giving a perfect idea of it, yet it enables us to draw one undisputable conclusion: the contemporary sea basins are new geological features whose existing boundaries probably were established only by the end of the Tertiary period and whose final contours were delineated in the Quaternary period. It is evident that the geological processes that determine the contours and relief of contemporary sea floors have not been interrupted at the present time. One of the objectives of marine geology is the establishment of the character and direction of movements of the earth's crust in the coastal belt and bottom areas of contemporary seas.

Evidently, with increase of our knowledge, we shall have to single out a mixed type of sea basins, in addition to the platform and typical geosynclinal seas, i.e. a type whose various parts are of different origins.

The bottom relief and contours of a sea, and consequently the character of its connection with the world ocean, are determined by the geological history of the sea. These characteristics, in turn, determine the hydrological, specifically the hydrodynamic, regime of a sea. In interaction with the basic geological factors, the processes occurring in the water and air layers of the earth as a result of solar energy, which is manifest in climatic zonation, stand out.

The degree of separation of a sea basin from oceanic circulation causes regular changes in the hydrological regime (N. N. Zubov, 1938) and, as a consequence, changes in the process of sedimentation, notably with respect to organic substances, sesquioxides and other components of chemical composition of sediments whose reaction to changes in the hydrological regime are most sensitive (M. V. Klenova, 1948).

While the hydrodynamical impact of water on the assortment of sediments, i.e. on their mechanical composition, is manifest in all basins notwithstanding their type, the effects of purely hydrological and hydrochemical forces leads to changes in the process of sedimentation insofar as the composition of sediments is concerned, in other words, to changes in certain aspects of the (sedimentation) process. The characteristics of relief and contours of a sea, which are associated with the geological structure of its floor and coast, have an essential effect also on the hydrodynamic processes occurring in it, though, naturally, the essence of the latters effect on sedimentation does not change. The main characteristics of relief which reflect in hydrodynamic processes are the disjunction and steepness of its slopes. As has already been pointed out, the slopes - notably the coastal slope as well as the slopes of underwater elevations - serve as an area of most intense hydrological, hydrochemical and biological activity in the sea (M. V. Klenova, 1934, 1948). This, in turn, is indirectly reflected in the process of sedimentation, particularly, in the distribution of sediments over the bottom.

As was pointed out above (table 1), the Barents Sea belongs to the platform category of seas having a wide contact with the ocean. The major portion of its area lies at depths not exceeding 300 m; only in the Central Depression the depth increases almost to 400 m, but in the Western Trench bordering the Greeland Sea (it increases) to 500 m.

The bottom relief of the Barents Sea reflects the complex history of the Barents Sea Plain. Only detailed surveys enabled us to obtain a correct concept of the bottom relief. The bathymetric chart by F. Nansen (1904) presented the first general idea of the complex bottom relief of the Barents Sea. The next mile stone was the bathymetric chart by N. N. Zubov (1931) which was already based on the data from Soviet expeditions (fig. 13). The chart made it possible to single out the basic elements of bottom relief of the Barents Sea and later, to make an attempt to present a geological interpretation of the relief (M. V. Klenova, 1933, 1935). Further studies of the relief conducted by the Laboratory of Marine Geology of the Polar Institute of Fisheries and Oceanography (P. S. Vinogradova, 1957), specifically the echosounding survey, disclosed a number of details lacking on the preceding charts due to a limited number of measurements, but they did not alter the basic character of the main elements of bottom relief. The elements are as follows: the banks of the southern part of the sea - the Kanin, Murman and Goose banks (Kaninskaya banka, Murmanskaya banka, Gusinaya banka); the Nordkapp Trench, (Nordkapskiy Zhelob); the Central Depression (Tsentral'naya vpadina); the Western Trench (Zapadnyy Zhelob); the Northern Shoals

of Novaya Zemlya (Severnoye Novozemel'skoye melkovod'ye); the Central Elevation (Tsentral'naya Vozvyshennost'); the Bear-Spitsbergen Shoal (Medvezhinsko-Shpitsbergenskoye melkovod'ye); the Persey Elevation (Vuzvyshennost' Perseya); the Northern Plateau (Severnoye plato); and a sloping elevation between the Western Trench (Zapadnyy Zhelob) and the Central Depression (Tsentral'naya vpagina), the Central Plateau (Tsentral'-naya Plato); the Pechora Shoals or Shallows (Pechorskoye melkovod'ye) and Pre-Novaya Zemlya Trench (Prinovozemel'skiy Zhelob) (fig. 14).[1]

The typical features of the continental shelf of the Arctic Ocean are more or less extensive bottom depressions in a general meridional direction between which the continental shelf declines toward the north. Within the limits of the Barents section of the continental shelf the feature is manifest in the form of depressions to 350 to 400 m in the central /67
part of the sea - namely, in the Central Depression (Tsentral'naya vpadina), the Northeastern Depression, the Franz-Viktoria Trench (Zheloba Frants-Viktoriya) on the west and in Polar Basin Bay (Bykhta Polyarnogo basseina) in the east of Franz Josef Land (Zemlya Frantsa Iosifa).

[1]The bathymetric chart (fig. 14) was based on P. S. Vinogradova's chart to lat. $78^{\circ}30'$ N and on the chart of Morskoy Atlas (vol. 1, plate 8, 1950) for the northern section of the Barents Sea and the slope of Arctic Basin.

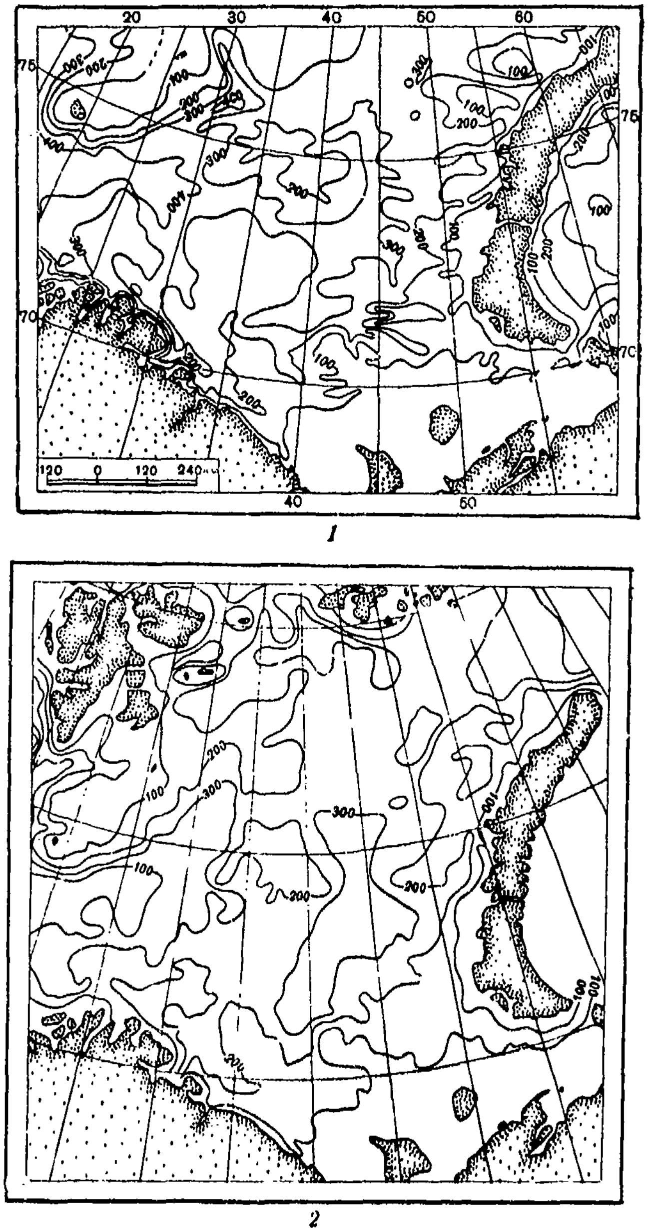

Fig. 13. Bathymetric Charts of the Barents Sea

1 -- according to F. Nansen (1910);

2 -- according to N. N. Zubov (1931).

In the southern part of the Barents Sea the direction of relief features is determined by the northeastern slope of the Fenno-Scandinavian Shield. All the other relief features between the south island of Novaya Zemlya, the Vaygach and Pay-Khoy islands, on the one side, and the Kanin and /68 Kola peninsulas (poluostrov Kanin and Kol'skiy poluostrov), on the other side, extend in a northwestern direction. On the eastern Murman the metamorphic complex of the Fenno-Scandinavian Shield is interrupted in the sea and the depth reaches rapidly 100 m, but detailed measurements (P. S. Vinogradova, 1957) demonstrated that a series of underwater mounds stretch along the coast. Also the underwater elevation of Kildin and Rybach'ya Shoals (Kildinskaya and Rybach'ya banki) are stretched out in northwestern direction.

The Rybach'ya Shoal or Bank, separated from Rybachiy Peninsula (poluostrov Rybachiy) by a relatively deep trench, is bounded in the north by the eastern branch of Nordkapp Trench (Nordkapskiy Zhelob). To the north of the Kanin Bank,which is bounded by a 100 m isobath, stretches the Murman Shoal (Murmanskoye melkovod'ye) in the same direction to a depth of 150 m and the Murman Bank (Murmanskaya banka). Their spurs, at depths exceeding 250 m reach the area of the Western-Bear Trench (Zapadnyy-Medvezhinskiy Zhelob).

In addition to underwater mounds stretched in northwestern direction there are several depressions stretched in the same direction on the extension of the Nordkapp Trench. These depressions lie between the coast of Kola Peninsula (Kol'skiy poluostrov) and the elevation of the

Kanin Bank on the extension of the Kanin Nose (Kaninskiy Nos) and the Murman Shoal (Murmanskoye melkovod'ye).

Farther to the west the basic element of bottom relief is the Nordkapp or Norwegian Trench. The deepest part of the trench (with depths exceeding 350 m) adjoins the Nordkapp where an isolated and slightly elongated depression is formed in a northwestern direction. Still farther to the west, the bottom relief becomes exceptionally complex but the section lies beyond the limits of the Barents Sea region that has been investigated - i.e. on the line Nordkapp-Bear Island (Nordkapp-Bjørnøya or Nordkapp-Ostrov Medvezhiy).[1]

The deepest section of Norwegian Trench, which is located within the confines of the Barents Sea and is adjacent to the coast of Finmarken on the northeast, northwest and north, is surrounded by elevations approximately 250 m deep.

The central depression of the Barents Sea is separated from the Western-Bear Trench (Zapadnyy-Medvezhinskiy Zhelob) by a flat elevation of the Central Plateau whose depth is approximately 250 m; toward the north the

[1] The assumed boundary of the Barents Sea-Cape Nordkapp-Bear Island, as a number of other geographical boundaries that have been assumed earlier, do not coincide with the geological structure of sea floor. The border based on the line of depth between the Barents and the Greenland sea, which has been proposed by the Polar Institute of Fisheries and Oceanography (P. S. Vinogradova, 1957) is more correct because it reflects not only the hydrological and hydrobiological characteristics of the area but also the geological structure of sea floor. This border is accepted by A. M. Muromtsev (1953) for a scheme presenting the divisions of the World Ocean.

plateau merges with the Central Elevation of the Barents Sea. With increase in the quantity of measurements, the Central Elevation assumes more and more intricate contours. As can be seen from a chart (fig. 14), at present the elevation can be considered as consisting of two parts situated obliquely with respect to each other and slightly elongated in the northeasterly direction. The underwater valleys on the slopes of the Central Elevation run in various directions - now toward the Central Depression, now toward the Western Trench. The Central Elevation is connected with the Persey Elevation by a sloping saddle, but its south-eastern section is adjacent to the Central Plateau; during the drying period of the Barents Shelf here evidently stretched a watershed between the Western Trench and the Central Depression, its direction being almost north-south.

The northeasterly direction of individual sectors of the Central Elevation coincides with the same direction of the elevation of the Gorbovyye Islands (ostrova Gorbovy) and the northern island of Novaya Zemlya, as well as with the Bear-Hopen (Medvezhinsko-Nadezhdinskoye melkovod'ye). The latter, whose depth is approximately 100 m, stretches in a nearly north-south direction with a slight declination toward the northeast.

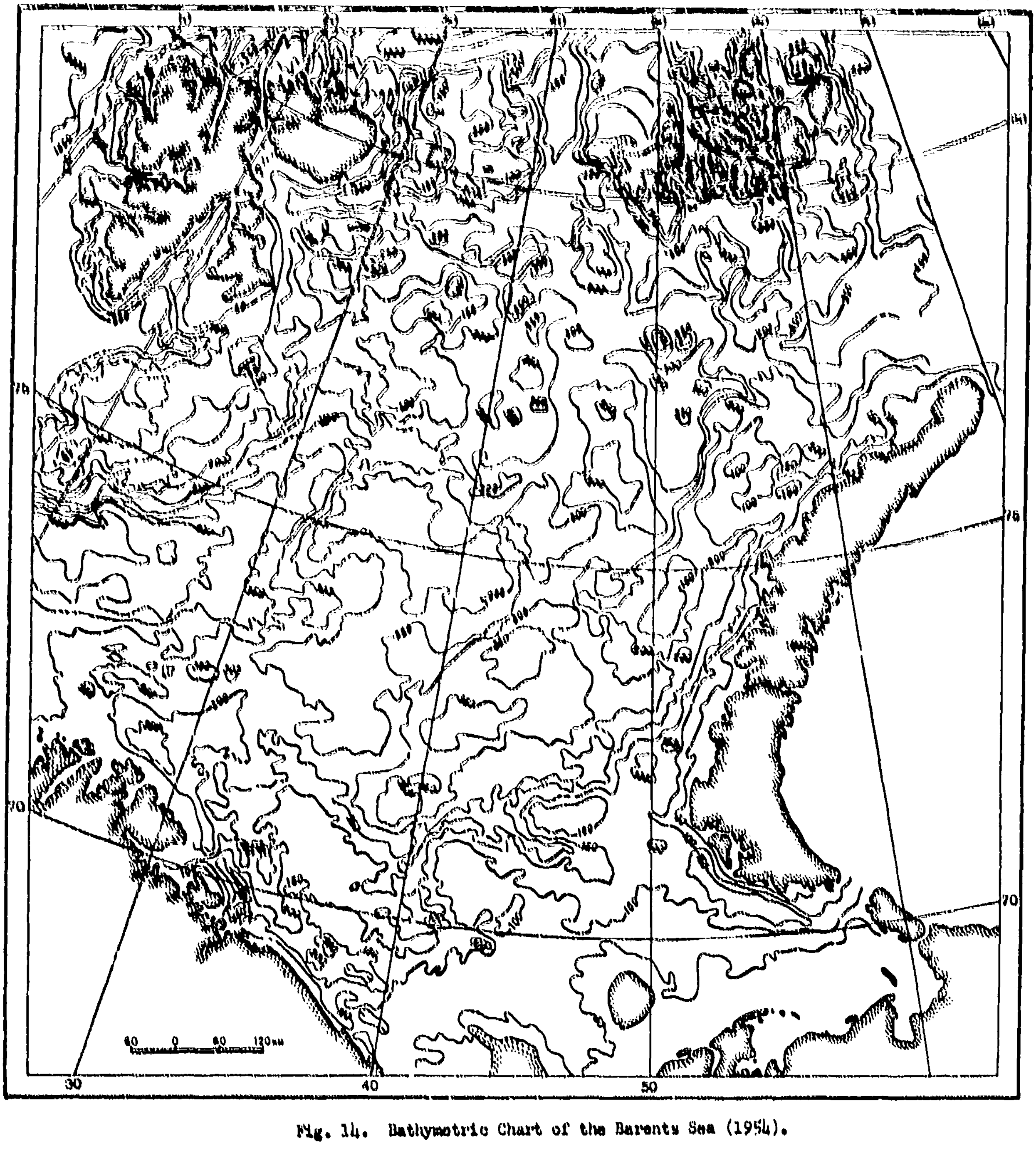

Fig. 14. Bathymetric Chart of the Barents Sea (1954).

M. B. Kasnoss

Thus, most of the relief features in the central section of the Barents Sea have a linear character and, as has been pointed out more than once (N. V. Klenova, 1933, 1935), extend in the predominant direction of the rocks lying on the coast.

In the northern part of the Barents Sea Plain, the character of the relief changes. Except for the Bear-Hopen Shoal (Medvezhinsko-Nagezhdinskoye melkovod'ye), which is a continuation of the eastern parts of Spitsbergen Archipelago and the Bear Island (Bjørnøya or ostrov Medvezhiy) with its rocks stretching in a nearly north-south direction, all the remaining bottom area is covered with a series of depressions and elevations whose formations are rather intricate at the first glance. With more precise knowledge of the relief, the structural characteristics in the area appear more pronounced and we can see an analogy of the region, with the structure of the Archipelago of Franz Josef Land, for instance. As was pointed out above, the archipelago is characterized by an alternation of deep straits in north-south and east-west directions which owe their origin to offset faults.

The valleys lying on the bottom of the Barents Sea have a north-south direction between the Nordaustlandet (Northeastern Land) of Spitsbergen and White Island (Kvitøya or ostrov Belyy) as well as to the north of the island on the slope of the Polar Basin. A similar valley is silhouetted between the White Island (Kvitøya or ostrov Belyy) and Viktoriya Island (ostrov Viktoriya). Its extension northward from a shoaling dike between the islands cuts deeply into the slope of the Arctic Basin.

The depression lying between the Viktoriya Island (ostrov Viktoriya) and Alexander Land (Zemlya Aleksandry) - that is, the Frans-Viktoriya Trench - changes its direction from north-south to east-west in the north and back to north-south in the south at its junction with the system of the Central Depression of the Barents Sea. The northern and southern parts of Persey Elevation (Vozvyshennost' Perseya), as well as the underwater base of King Karl Islands (Kong Karls Land) are stretched out in an almost east-west direction.

The number of depth measurements in the part of the Barents Sea is far from satisfactory for a perfect concept of its relief. However, the disclosed trends are well expressed on bathymetric charts. Further measurements and geological studies must solve the problem of northward extension of the Central Depression of the Barents Sea - namely: whether it is extended into the Bay of Polar Basin or it is merging with a depression lying to the west of the elevation of Franz Josef Land on the southern slope of the Arctic Basin.

The surface of depressions and elevations of the Barents Sea Plain is undulating, the variations being insignificant, except for the slopes of elevations where the relief is usually complicated with individual terraces, underwater valleys and ridges. A great stability of the relief elements of Barents Sea can be pointed out. On profiles (fig. 15.1) it is expressed by a similar depth of branching peculiar to one or the other elevation, but on a bathymetric chart (fig. 14) by isobaths running more or less parallel to one another. The contours of isobaths at

various depths repeat one another fairly well. The underwater valleys lying between separate elevations and on their slopes are outlined. Thus, the valley lying between the north island of Novaya Zemlya and the elevation of Gorbovyye Islands (ostrova Gorbovy) is marked by the 200 m isobath. A similar clearly pronounced valley separates the Gusinaya Shoal or Bank together with the shoal connecting it with Goose Island (Gusinaya Zemlya) from the Northern Kanin Bank (Severo-Kaninskaya banka), the Kanin-Kolguev Shoal (Kaninsko-Kolguyevskoyo melkovod'ye) and from the base of Kolguev Island (ostrov Kolguyev). Both of the valleys seem to merge with the Central Depression of the Barents Sea. The underwater valley lying between the Northern Kanin Bank and the Murman Bank converge with the southern end of the Central Depression. A number of valleys can also be noticed on the southern slope of Murman Bank in the region of Rybach'ya and Finmarken Shoals (Rybach'ya and Finmarkenskaya banka) where the slope of valleys is directed toward the eastern branch of Norwegian Trench and toward the northern part of Varanger Fjord (Varangerfjord).

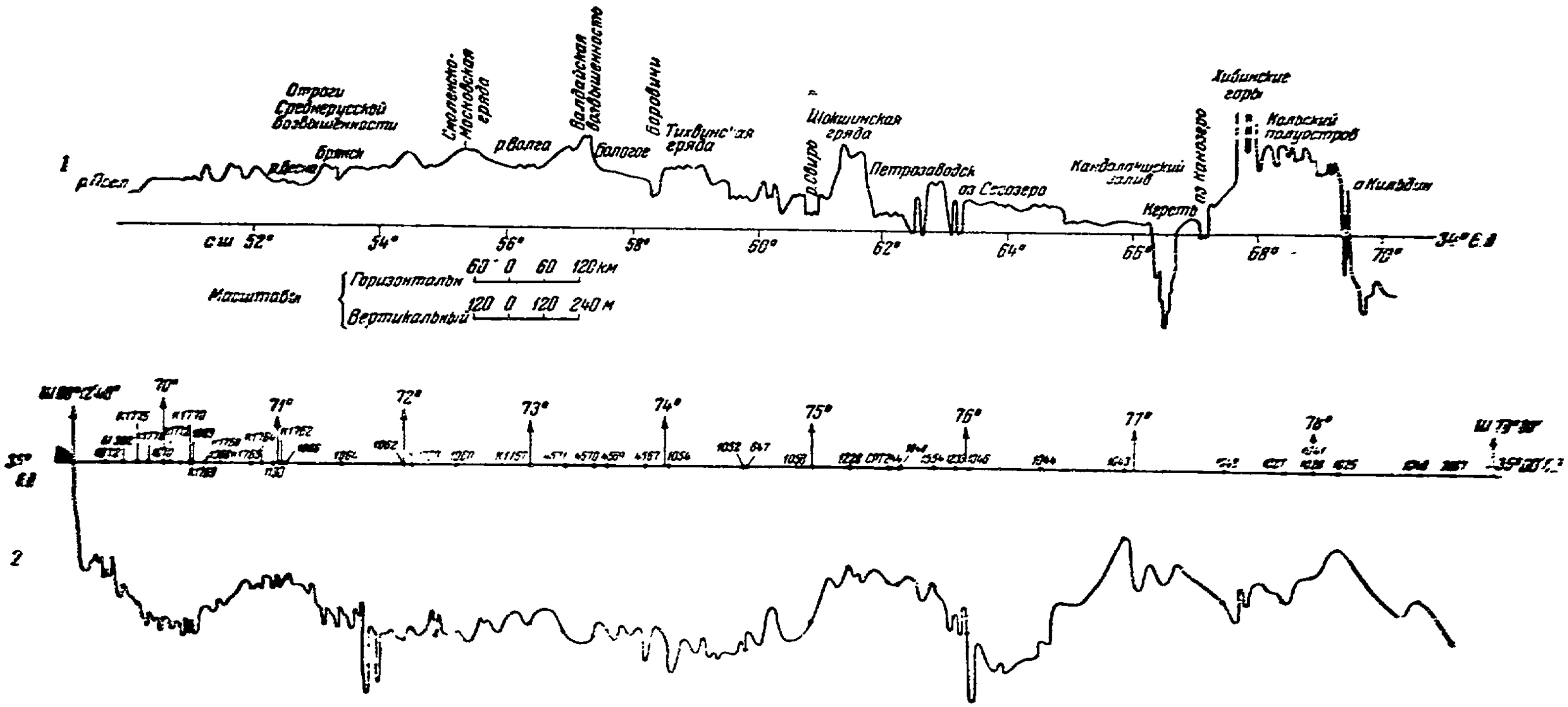

Fig. 15. 1 -- a schematic profile of Russian Platform along long. 34° E;
2 -- bottom profile of the Barents Sea along long. 35° E.

Key. From left to right. (Curve 1): River Psel, spurs of Russian Central Highland, River Desna, Bryansk; the Smolensk-Moscow Ridge, River Volga, the Valdai Highland (Valdayskaya vozvyshennost'), Bologoye, Borovichi, Tikhvinskaya Gryada; River Sibir', Shokshinskaya Gryada, Petrozavodsk, Ozero Segozero (lake), Kandalakshskiy Zaliv, Keret', Ozero Kanozero (lake); Khubinskiye Mountains (Khubinskiye Gory), Kola Peninsula (Kol'skiy poluostrov), Kil'din Island (ostrov Kil'din). (Curve 2): upper left-hand line: lat.
middle left-hand line: long. E.

It is noteworthy that the branching of underwater slopes occurs at certain depths in the entire Barents Sea area, notably from 100 to 200 m.

On the Bear-Spitsbergen Banks (Medvezhinsko-Spitsbergenskoye m.) the underwater valleys are defined with an exclusive clarity as to the isobaths on the slope of the West Spitsbergen Island (Vestspitsbergen) with its deep and wide fjords. It can be readily seen that with the lowering of sea level by only 100 m the entire Bear-Spitsbergen Banks (Medvezhinsko-Spitsbergenskoye m.) becomes one island with deep fjords (Isfjorden, Bellsund, Hornsund, Sørkapp Trench, a fjord to the north of the present Bear Island (Bjørnøya or ostrov Medvezhiy)) directed toward the Greenland Sea Depression and having less deep bays on the eastern side.

In order to compare the bottom relief of the Barents Sea with the relief of the Russian Platform, we prepared a schematic profile (fig. 15.1) along the 34th meridian of the Dnepr Basin (River Psël) across the spurs of the Central Russian Highland, the Valday Highland (Valdayskaya vozvyshennost'), Tikhrinskaya Gryada, Shokshinskaya Gryada in Petrozavodsk area, Kandalakshskiy Bay (Kandalakshskiy zaliv), Kola Peninsula (Kol'skiy Poluostrov) and Kil'din Island (ostrov Kil'din), which was plotted in an exaggerated scale to make it correspondingly analogous to the profiles of the Barents Sea. If the ratio of vertical and horizontal scales is 1:500, the relief of the Russian Plain with its sloping highlands is analogous to the relief of the Barents Sea platform (fig. 15.2).

Typical are the undulating surface at various depth levels, maintained depth of branching for each positive relief element and complicated character of slopes, which is underscored by the direction of profiles along meridians without accounting for the actual extension of relief elements. Steeper slopes, which as a result of the distorted scales approach the vertical, can be seen in the areas characterized by fractures on the northern slope of Shokshinskaya Gryada, at Kandalakshskiy Bay (K. zaliv), on the northern slope of Kola Peninsula (Kol'skiy poluostrov) and on Kil'din Island (ostrov Kil'din).

As had to be pointed out more than once, the Central Depression of the Barents Sea and the Northeastern Depression to the north of the former, which farther merges with the Polar Basin Bay (Bukhta Polyarnogo basseina), represent a very old structural element of the earth's surface. We consider it as the northern extension of the Caspian-Pre-Ural Flexure (Kaspiysko-Predural'skiy progib) (1948), which is extended also southward toward the Indian Ocean and its boundaries.

N. S. Shatskii (1948) considers the flexure - i.e. the East Russian Flexure Zone - as a complex structure of the highest order unifying a series of synclines and antisynclines whose development started by the end of Devonian age. According to N. S. Shatskii, in the Devonian age, the entire structure of the Russian Platform was almost exclusively determined by the general East-West structures. During the folding of the East Russian Depression, which was especially intensive in the Carbonaceous period and continued in the Permian epoch, the East-West

structures assumed a subordinate significance. To a degree they appeared by the end of Permian epoch and in the Triassic period, but, on the whole, in the Mesozoic and Cenozoic eras continued a deep sagging of the East Russian Zone - namely, the Pre-Caspian Depression and the Volga Syncline.

N. S. Shatskii assumed that the flexure is gradually wedging toward the Kama Basin. However, the compilation of data obtained from drillings (A. A. Bakirov, 1954) shows that the Kama-Pechora (Kamsko-Pechorskaya), the Saratov-Ryazan' (Saratovsko-Ryazanskaya) and Pre-Caspian depressions form a series of formations stretched out in a general north-south direction and having several bends which seem to bypass individual ledges of a crystallic foundation. The depression system can be readily continued northward across the neck of the White Sea (Gorlo Belogo Morya) toward the Central Depression of the Barents Sea. This pres nts a possibility to talk about a continuous chain of features which at places deviate from north-south direction by projecting blocks of crystalline /72 foundations - which are evidently the remains of ancient East-West structures.

It can be mentioned that, according to the distribution of magnetic anomalies, A. D. Arkhangel'skii (1937) established the presence of the same trends in the pre-Cambrian layer and pointed out that the east-west system is older and that the north-south system bends around it. On the Kola Peninsula (Kol'skiy poluostrov), however, the north-south formations of Archean rocks appear to be older, while the northwestern

formations are patterned after the Proterozoic foldings (the Baykal or reef-shaped, according to N. S. Shatskii).

As was pointed out by A. P. Karpinskii (1919, 1939), a characteristic feature of the structure and development of the Russian Platform is the alternation of basins extending in a nearly east-west direction with the basins extending in nearly north-south direction (p. 123). According to A. P. Karpinskii, the greater part of the dislocations on the Russian Platform are associated with alternation of north-south and east-west depressions. In the relief of the Barents Sea Plain these structural features are also expressed clearly enough.

All the other relief elements between the south island of Novaya Zemlya, Vaygach and Pay-Khoy, on the one side, and the Kanin and Kola peninsulas (poluostrov Kanin and Kol'skiy poluostrov), on the other side, are stretched out in northwestern direction. As is known, the pattern has a reef-shaped folding on the Varanger (Varangerhalvøya) and Rybachiy peninsulas (poluostrov Rybachiy), on ostrov Kil'din, the Kanin and Timan.

The underwater elevations that are stretched out in northwestern direction along the coast are, of course, composed basically of old, undoubtedly, pre-Cambrian rocks and have a common origin with the remains of reef-rock foldings of Varanger (Varangerhalvøya) and Rybachiy peninsulas and Kil'din Island (ostrov Kil'din). During the later geological processes they were intensely levelled off and covered by clayey sediments, or possibly, by glacial formations.

Thus, the weak marks of pre-Cambrian foldings that stretch along the northeastern and northern slopes of the Fenno-Scandinavian Shield can be traced from the Timan-Kanin zone throughout the entire system of the relief elements described above. The existence of an older north-south flexure is expressed in the system of relief elements in the form of a valley stretched in northwestern direction, which has been possibly used in a regression stage of a great river flowing from the Russian Plain (the predecessor of Severnaya Dvina).

During the Caledonian period of tectogenesis the basic folding occurred to the west of the Bering Sea Platform, but the traces of Caledonian movements are also found in its southern and eastern sections.

The Caledonian foldings, which to the west of the Fenno-Scandinavian Shield are stretched out in nearly north-south direction, cut off the Proterozoic folds and proceed, in the north, along the west coast of Spitsbergen. It is interrupted by the Western-Bear Trench (Western-Medvezhinskiy Trench), which is evidently a newer relief element dissecting the old folds. The Caledonian foldings of Norway have renewed the system of north-south formations of older periods. On land there is only one place where at the present time one can find Caledonian folds intersecting the preceding reef-rock formations - namely: Finmarken and Varanger peninsula (Varangerhalvøya). Here the north-south formations deviate slightly toward the northeast and the Caledonian movements reshape to a degree the older foldings. The process is accompanied by numerous fractures, faults and overthrust foldings. A relatively

unstable region is formed here. The coastal contours and bottom relief become extremely complex. The formation of bottom relief in this region which is determined by a system of numerous fractures and faults, is elucidated by O. Holtedahl (1940).

On Spitsbergen the Caledonian folds preserve north-south and northeasterly direction. The latter is determined here, evidently, by the western edge of the Central Barents Sea Platform. The Caledonian movements also reshape to a degree the oldest rocks of the Nordaustlandet (Severo-Vostochnaya Zemlya) where the foldings and the degree of metamorphosis of rocks become gradually extinguished from the west coast of Spitsbergen eastward (K. Sandford, 1950). The northeasterly formation have been preserved in the bottom relief of the Central Elevation. As was pointed out above, only weak traces of Caledonian folds are found on the Northern Ural Mountains and on Novaya Zemlya, which at times reflect only interruptions of sediments. In the southern section on Kanin, Pay-Khoy and on the south island of Novaya Zemlya it is subordinated to northwesterly formations of older folds. Farther to the north, the shoals (melkoved'ye) adjacent to the North Island of Novaya Zemlya in the area of Gorbovyye Islands (ostrova Gorbovy) and partly on Gusinaya Shoal can be considered as the remains of Caledonian folds. These Caledonian elevations served as a source of material for the Silurian Sandstones and conglomerates of the North Island of Novaya Zemlya. They were evidently formed along the eastern edge of the Central Barents Sea Platform, limiting from the east the system of the oldest north-south depressions. /73

As on the Russian Platform, the formations of the oldest reef-rock formations which are stretched out approximately in a east-west direction have been replaced by north-south and northeasterly formations of Caledonian structures. By the end of Caledonian period, a general rise of the Russian Platform took place, as one can see when examining the geological structure of the Barents Sea coast, also the western part of continental shelf, which is now covered by the sea, was subject to a continental regime.

In the Devonian period began the sinking of the eastern part of Russian Platform, which continued to the end of the Paleozoic Era and was accompanied by a widening of the continent along the Baltic Shield. In analogy with the Russian Platform, one may think that the tendency toward rising was also preserved to the northeast of the Baltic Shield within the limits of the southern part of the contemporary Barents Sea and contiguous to the Baltic Shield of reef-rock formations.

In further stages of development the north-south pattern, which was well pronounced in the Hercynian folding of the Ural Mountains, was subordinated to the direction of older structures in the Barents Sea floor, which were stretched out in northwesterly direction in the south and in northeasterly direction in the north and which led to a typical folding of the entire system of the Polar Ural and the foldings of Novaya Zemlya. The Hercynian foldings of Novaya Zemlya are slightly reflected in the system of Central and Northeastern depressions.

On the Barents Sea floor the traces of Hercynian foldings that had formed the two islands of Novaya Zemlya are weakly pronounced. Between the eastern edge of the Central Barents Sea Platform and, evidently, the rigid structure of the Kara Sea (Karskoye More) floor, the Hercynian foldings bend eastward and, interlocking with the foldings of Severnaya Zemlya - according to V. S. Tokarev - penetrate into the Polar Basin.

In the Post-Hercynian period, when the north-south pattern in the deepest depression of the Russian Platform was again replaced by the east-west pattern and the area itself was displaced toward the south and southeast, the sagging affected the northwestern portion of the Barents Sea, where its traces have been preserved on Spitsbergen in the form of thick layers of Triassic and Jurassic sediments. Also the southeastern portion of the sea, which adjoins the Pechora Depression (Pechorskaya depressiya) and is filled with Mesozoic sediments, was subject to sagging.

Thus we single out elements of various ages in the structural composition of the Barents Sea Platform (fig. 16). The most important and oldest structural element is the central flexure of the Barents Sea which /74 coincides with the system of its relatively deep depressions. In the southern part it adjoins the Pechora-Vaygach Depression which evidently appears to be a later formation because its axis coincides with the reef-shaped foldings. The southern portion of the Barents Sea with its system of sloping elevations and depressions having a northwestern direction is assigned by us to the area inherited from the Proterozoic foldings. It could be pointed out that in the southern portion of the Barents Sea,

the system of elevations crossing the north-south depression lends it a curved sweep. In the western part one can find traces of the Caledonian structures whose remains on the sea floor are evidently found along the banks of trenches in the Greenland Sea. A system of north-south or nearly north-south formations (northeasterly), possibly of Caledonian origin, can be traced on the Central Elevation and near the northern island of Severnaya Zemlya.

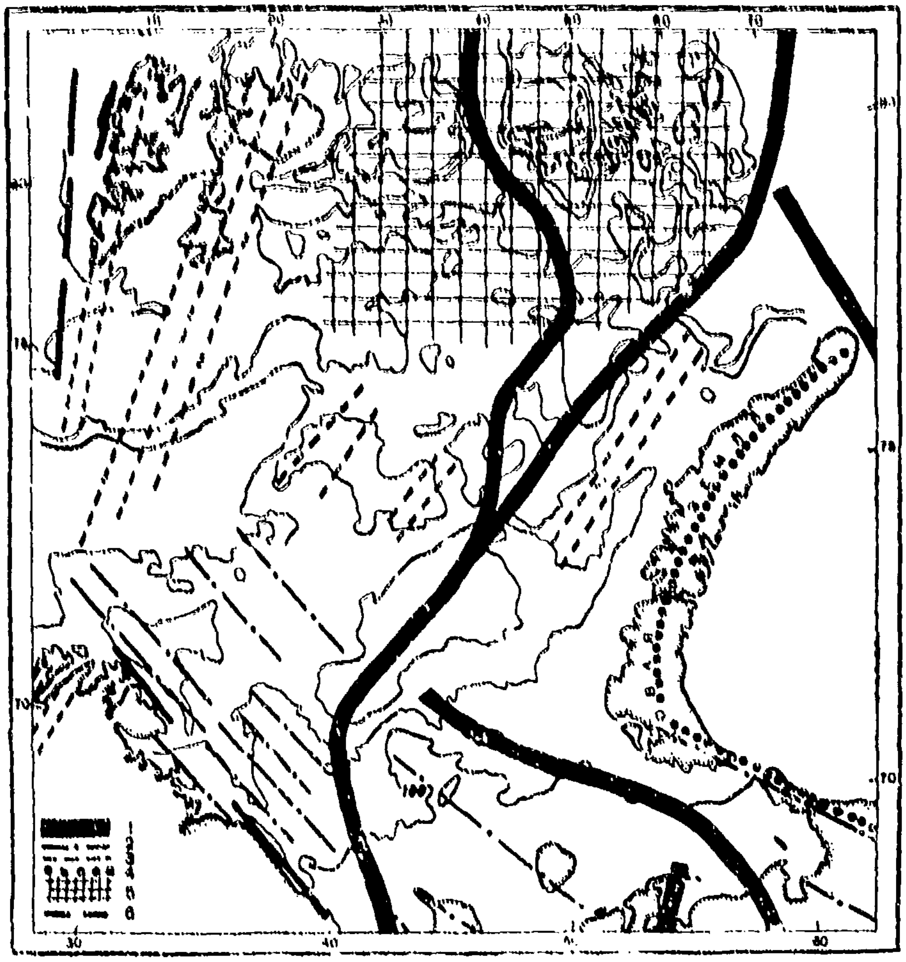

Fig. 16. Diagram of Barents Sea Structure.

1 -- axis of bends;

2 -- directions of Proterozoic folds;

3 -- Caledonian folds;

4 -- Hercynian folds;

5 -- Tertiary movements;

6 -- fractures.

The Hercynian folds locking the Ural-Novaya Zemlya geosynclinal area came across the rigid structures of the Barents Sea floor, which had been formed earlier, and so we cannot find more or less dependable traces of the foldings. It is possible that during the period the movements on the Barents Sea floor, as well as in the areas of Kanin, Timan and Novaya Zemlya, occurred in the same direction as in the case of Caledonian movements.

In the northern section of the Barents Sea, an area of Tertiary movements, notably of the disjunctive type, stands out. This is the oldest section of the Barents Sea Plain which began to sag in the Jurassic period. Evidently, the sagging was accompanied by fractures and basalt eruptions, continued to the Quaternary period and is continuing also at the present time - though in a more quiet way - in connection with the formation of the deep depression of the Arctic Ocean.

New fractures bound the Barents Sea floor from the side of Kola Peninsula (Kol'skiy poluostrov) and Finmarken, as well as near Novaya Zemlya, along the coast of Franz Josef Land and Spitsbergen Archipelago. They undoubtedly exist at places on the sea floor, reflecting on echograms in the shape of steep banks, as for instance at the west end of Goose Shoal (Gusinaya banka), in Pre-Novaya Zemlya Trench (Prinovozemel'skiy Trench) and in other places (P. S. Vinogradova, 1957).

Comparisons of the history of geotectonic development in the Russian Platform and the continuation of the latter northward under the Barents Sea floor shows with a complete obviousness that shifts from north-south

to east-west patterns are general in character. V. V. Belousov points out (1954) that despite the failure of many attempts in "geometrizing" the structure of earth's surface, "certain geometric rules in the structure of earth's crust exist and they cannot be eliminated altogether from the account." (Page 11).

The analysis of bottom relief in the Barents Sea area and in other basins, the Caspian Basin for instance, raise an essential problem - namely: the structure of the so-called "intersections", i. e. the intersection areas of north-south and east-west patterns of elevations and depressions. As we already had to point out,[1] within the confines of the Caspian Sea one can see that deep depressions are formed at the intersections of two zones of depressions, as for instance the South Caspian Depression; a complex system of relatively small foldings, which leads to a great complexity of sea bottom, is formed at the intersection of the elevation of Caucasian Mountains with the northwestern and north-south patterns of Caspian Depression. One can think that it is in such intersection areas where the crystalline foundation and the lower structural layers of sediments are subject to stresses in various directions, which occurs in platforms as well as in geosynclines and leads to a considerable structural complexity of the areas. Evidently, in the latest stages of geotectonic development such areas are characterized by a maximum of mobility.

[1] Conference on tectonics of the Alpine geosynclinal area of the USSR from September 14 to 20, 1954.

In the Barents Sea one can find such a typical "intersection" in the southwestern part - Finmarken and Varanger Peninsula (Varangerhalvøya), as well as in the adjacent section of sea floor. Here a seam of Caledonian folds stretching in nearly meridional direction are found together with northwesterly formations of older reef structures. It is not by chance that a fracture whose character is evidently reminiscent of the fracture associated with the formation of the northern part of the Atlantic Ocean (A. V. Peive, 1945) did occur along the seam. Along the line of the fracture, a flexure of the sea bottom occurred on the slope, extending from the continental shoal of the Barents Sea westward to the great depths of the Greenland Sea.

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The absence of traces of the Caledonian foldings on the slope between Finmarken and Bear Island (Bjørnøya or ostrov Medvezhiy) appears to be rather puzzling. One may, evidently, think that this is associated with incomplete investigation of the bottom relief. Also geophysical investigation are needed in this case - investigations which would enable us to clarify the geological structure of Skandika G. De Geer - the contemporary Greenland Sea.

In the northern part of the Bering Sea the meridional pattern of Caledonian folds is cut off by the descending continental shoal of western depression of the Arctic Basin. The investigation of bottom relief to the north of Franz Josef Land along the slope of Arctic Basin enables us to elucidate the character of the contact. Undoubtedly, the combination of north-south and east-west fractures, which has created a network of

straits in the Franz Josef Archipelago, is genetically associated with the lowering of bottom in the western section of the Arctic Basin. Here, as in the west, an unstable zone has been formed, which may possibly be associated with the fracture determining the direction of the edge of the Barents-Kara Shelf that runs parallel to the Verkhoyansk folding of the Lomonosov Ridge (ANII, 1954).

In analogy with mountain regions, of which a concept of specific forms of tectonic movements causing a rise and rejuvenation of the relief of old structures (N. I. Nikolaev, 1954) is being developed at the present time, it can be assumed that the origin of the Barents Sea is associated with movements having opposite signs but being analogous with respect to their character. When the lowering of the North Atlantic and Arctic oceans took place, the Barents Sea Shelf was also sinking, but, in line with observations in the areas of ancient mountain formations, the rate at which the various structures sank was different, i.e. the lowering was subject to differential movements. This ultimately led to the preservation of reef elements on the sea floor, which are associated with geological structures of various ages and has determined the complex bottom relief of the Barents Sea. Further, the positive elements of bottom relief appeared to be coordinated with mountain structures of various ages.

The characteristics of bottom relief of the Barents Sea, which were discussed above, had been inherited from its past geological history. The present stage in the development of the relief is characterized by

the presence of underwater terraces and submerged coastal lines. As we already had to point out, the old coastal line of the Barents Sea that is most clearly pronounced (M. V. Klenova, 1931, 1939, 1948) is found at a depth of approximately 180 m in its eastern sector and approximately 220 m in the western section, the mean isobath being 200 m. This old coastal line and the underwater terrace serves as a favorite place for the accumulation of commercial fish, the cod for instance.

The presence of the old coastal delineation at the depth was established in 1931 on the basis of a thorough analysis of bottom relief (but not along the 200 m isobath, as it is assumed by A. P. Lisitsyn, and G. B. Udintsev, 1953) which makes it possible to detect clearly pronounced projections at depth even with the aid of a small number of measurements, which is in addition, accompanied by the accumulation of large fragments of rocks and outcrops of rocks occurring in their place of origin. This was found on the slope of Goose (Gusinaya banka) (fig. 17.1) and Bear Shoals (Medvezhinskaya banka) (fig. 17.2) and confirmed by numerous echo-soundings which were recently carried out by the Laboratory of Marine Geology PINRO. The extension of the 200 m isobath that is seen in the V-shaped curve (1931) serves as an illustrative example of the typical relief feature.

Also the underwater terrace or the surface of leveling is clearly pronounced at a depth of 70 m, notably in the southeastern part of the sea, where it also serves as a place for the accumulation of commercial fish and good catches.

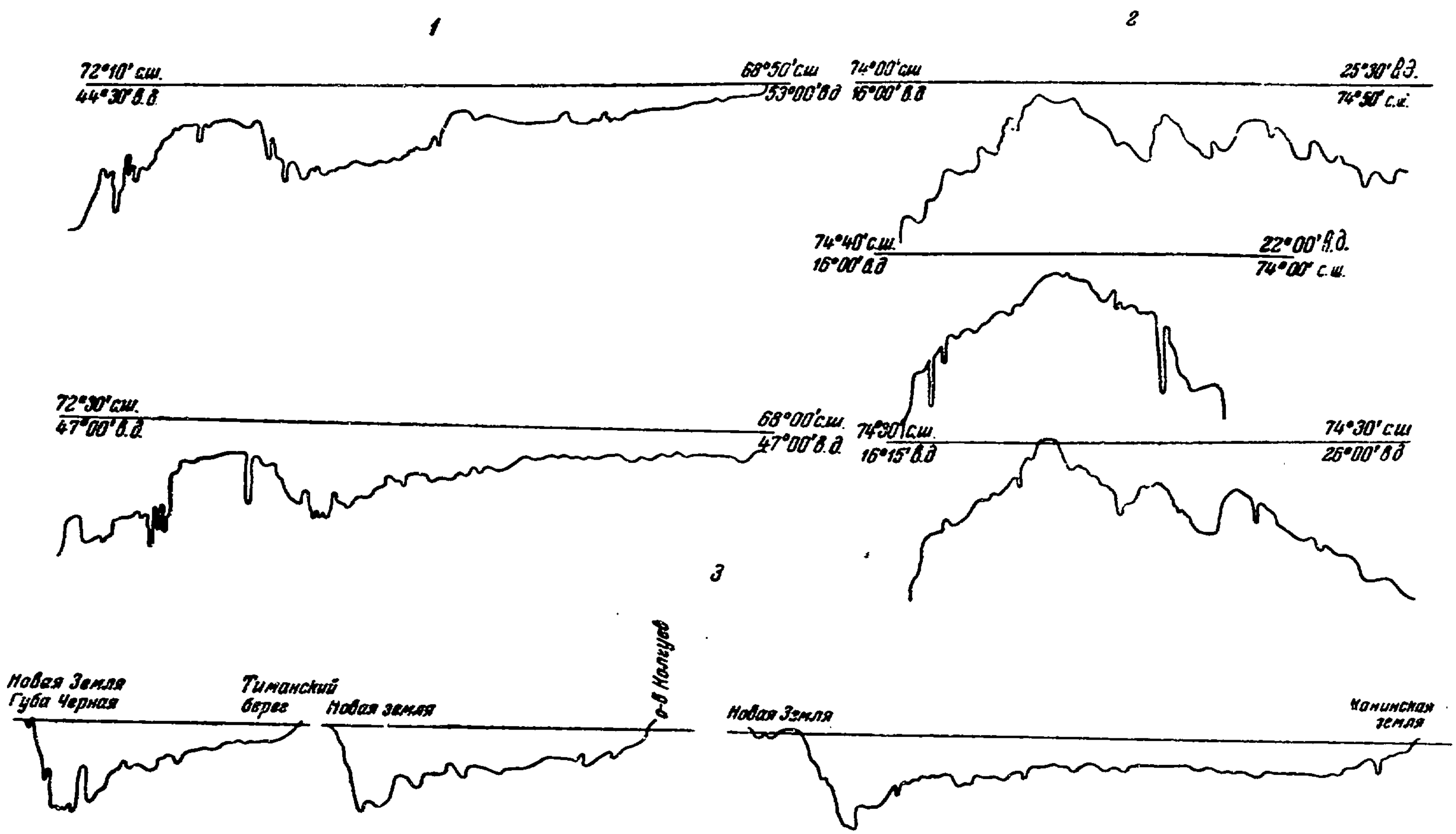

Fig. 17. Bottom Profile of the Barents Sea.

Scale: horizontal 0 - 100 km
vertical 0 - 400 m

1 -- slope of the Goose Bank (Gusinaya banka);
2 -- Bear Bank (Medvezhinskaya banka);
3 -- Novaya Zemlya Trench (Novozemel'skiy Zhelob).

С Ш - lat. N; В Д - long. E.

Lower line (left to right): Novaya Zemlya, Guba Chernaya; Timan Coast (Timanskii bereg); Novaya Zemlya; Kolguyev Island (ostrov Kolguyev); Novaya Zemlya; Kanin Land (Kaninskaya Zemlya).

As can be seen from the bathymetric chart (fig. 14), the 200 m isobath, as in the case of earlier bathymetric charts, is characterized by a maximum sinuosity. This, undoubtedly, indicates a rather long period during which the Barents Sea was confined within these limits, and a relatively rapid transgression of the sea to the present day boundaries during which the relief of coastal areas could not become leveled. The character of relief within the bounds of the 70 m terrace, on the contrary, shows that either the transgression was extremely slow in the areas or they were subject to more than one leveling and submergence. The latter supposition is more probable.

The presence of two main underwater stages on the Barents Sea floor we can see is the reflection of two mile stones in the history of Quaternary period, which is associated with two glaciations whose vestiges are most clearly discernible on the Russian Plain (M. V. Klenova, 1939).

In his review on the Quaternary period of the Arctic, V. N. Saks (1948) presents a table of Quaternary sediments in the western part of the Soviet Arctic, including the coast of the Barents Sea; the table is based on a more complete survey material.

In his study (1948) V. N. Saks objects to the view that the submergence of the coastal line of the Barents Sea to a depth of approximately 200 m occurred in the maximum glaciation but the submergence of coastal line to a depth of 60 to 70 m to the last glaciation. Besides, he remarks that during the Zyryanian Glaciation (Zyryanskoye oledeneniye) sea level was higher than at the present time because the glaciers descending from

Novaya Zemlya to the lower reaches of the Pechora River and Kolguyev Island (ostrov Kolguyev) brought materials characteristic of subaqueous deposits. According to V. N. Saks, the Pay-Khoy was inundated during the time. However, V. N. Saks mentions that in the epoch following the Zyryanian Glaciation a regression of sea took place along the entire Siberian coast. During the time, the rivers penetrated deeply into the sediments of glacial epoch, forming underwater beds to a depth of 50 to 60 m (V. N. Saks, 1948, p. 72).

According to V. N. Saks, the formation of Novaya Zemlya straits, the proliv (strait) Karskiye vorota for instance, had occurred during the glaciation maximum in the place of an old river valley.

In a later study, V. N. Saks (1953) ascribes the vestiges of the oldest coastal line, which was detected by us at a depth of 180 to 200 m, to the epoch of Zyryanian Glaciation, to which, in his opinion, also the formation of the sand-covered layer of sediments in the Arctic Ocean must be appertained. Judging by the radioactivity in sediments, the period characterized by a low coastal line ended 30 to 35 thousands years ago.

However, on the basis of new data, we are inclined to ascribe the old most clearly pronounced coastal line on the Barents Sea floor near the present 200 m isobath to the time of glaciation maximum. The supposition is supported by the indentation of the slopes between 100 m and 200 m isobaths, which may be associated with a erosional remnants of land denudation agents. Besides, the surface of the coastal plain was undulating

and, not abraded, submerged at a relatively rapid rate. This could happen as a result of eustatic rise of sea level associated with the melting of glaciers of the maximum glaciation.

The boreal transgression following the glaciation reached a height of 100 m above the present sea level and was accompanied by the appearance of warm-blooded fauna. It is possible that one of such transgressions was the White Sea transgression that rose 40 m above the present sea level and was mentioned by M. A. Lavrova (1937) as pertaining to the White Sea and the Pechora.

The submerged coastal line or the surface that had been leveled to 70 to 100 m (fig. 18) corresponds to the last great glaciation. The bottom relief above the depth differs considerably from deeper areas by its leveled surface. Sharp shifts in depth are absent here; even on a distorted scale (fig. 17.2) the bottom surface is only slightly undulating. Only a very thorough analysis enables us to detect the traces of the Pechora valley and other large valleys on this surface, which are very clearly pronounced on the relief between 100 and 200 m. This is a consequence of repeated alternating transgressions and regressions. The reason favoring the great age of the coastal line near the 200 m isobath is also the presence of completely abraded (rounded) stones found at considerable depths, while at smaller depths a fresh material predominates (M. V. Klenova, 1939). /79

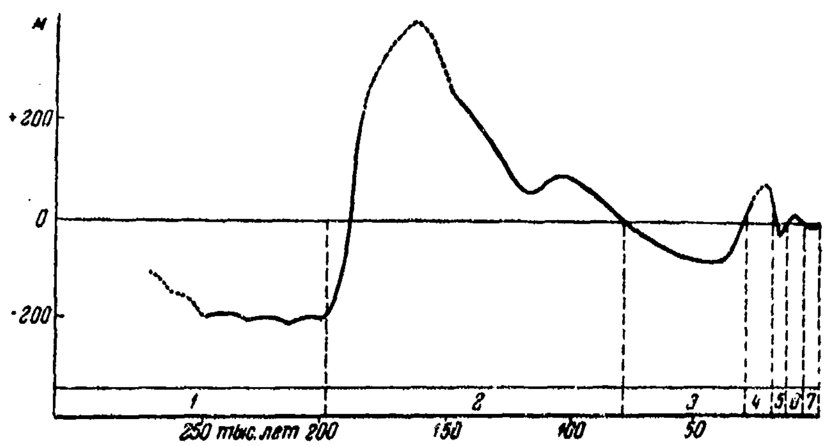

Fig. 18. Fluctuations of Barents Sea Level in the Quaternary Epoch.

1 -- maximum glaciation Q_3; 2 -- interglacial transgression (boreal); 3 -- last glaciation - Q_4; 4 -- late glacial transgression; 5 -- regression; 6 -- postglacial transgression; 7 -- regression and contemporary transgression.

Dotted lines show the posit'on of sub-aerial terraces associated with the rise of land.

X-axis: 250 thousand years 200 . . . .

One cannot agree with the suggestion of V. N. Saks that the old 200 m coastal line pertains to the period of Neo-Quaternary (Zyryanian, according to his terminology) glaciation. There is no need to associate the formation of the old coastal line with the coarse-grained sediments found in the Arctic Basin.

A simple arithmetic counting demonstrates that if the sandy depth level has been formed 40 thousand years ago, the rate of sedimentation should have been 6 mm a year. During the time, several transgressions and regressions have taken place and therefore, assuming that the coastal line is so young, one must admit that the contemporary movements in the Barents Sea area occur at a very great speed, exceeding on the average even the speed of movement of folds in the Caucasus where, according to the majority of investigators, the average speed of movements does not exceed 1 to 2 mm a year.

V. N. Saks points out a limited contact of the Arctic Ocean with the Atlantic Ocean during the formation of sand deposits. However, a complete drying of the Barents Sea was not necessary for limiting contact; the presence of thick ice ridges sliding into the sea from Greenland, Fenno-Scandinavian Shield, Novaya Zemlya, Spitsbergen and Franz Josef Land /80 would suffice. A final solution to the question on the age of submerged coastal line of the Barents Sea can be achieved only after thorough investigations.

If the "Sartanian" (Sartanskoye) glaciation of V. N. Saks, which, he thinks is characterized by the "gray clay deposits" in the Barents Sea, is considered as the last stage of the Neo-Quaternary glaciation (Valday Gl.), it should have taken place 10 to 12 thousand years ago. The post-glacial transgression, pertaining to the Tapes period 5000 to 8000 years ago did not rise higher than 6 to 15 m above the present sea level.

Later, according to V. N. Saks (fig. 19), began the general uplift of the Arctic which, he thinks, is reflected, as stated by M. M. Ermolaev (1948), in the sediments of the Arctic Ocean and the Kara Sea (Karskoye more) by an increased quantity of manganese. Thus, the main periods of the Quaternary history, which have been established for the North Europe, are also found within the confines of continental shelf of the Arctic Ocean and the portions of land adjacent to it. However, the question on their duration and the absolute age of one or the other period is not yet clear. In order to find a final solution to the question, there is needed not only a thorough investigation of deposits in the Arctic Ocean but also the deposits of its marginal seas. Such investigations must be, first of all, carried out in the Barents Sea. Here they will enable us to compare not only its history with the history of the entire Arctic as a whole but also to resolve a number of disputable questions on the Quaternary geology of the North European part of the USSR of which no postulations of general acceptance exist to the present time.

As can be seen by examining the geological structure of Barents Sea coast, in the Post-Hercynian epoch, the segment of the earth's crust has

been developed in accordance with the platform type, except for the west coast of Spitsbergen and, possibly, the underwater slope adjacent to it (H. Frebold, 1950). By the end of Tertiary period, in connection with the lowering of the northern section of the Atlantic Ocean and the formation of the Greenland Sea and the western depression of the Arctic Basin, the patterns of old movements reappeared in the Barents Sea Plain. The fractures and subsidences accompanying the movements led to the penetration of Atlantic waters and the emergence of a basin preceding the contemporary Barents Sea. This occurred, evidently, as early as in the Mid-Quaternary period. The present day position of the old coastal lines on the Barents Sea floor does not permit us to talk with a complete conviction of its earlier boundaries because the individual sections of the sea floor and coast have been subject to differential movements. Novaya Zemlya, for instance, rose to a height of not less than 240 m, but the corresponding terraces on the Kolguyev are at a height of 70 m, on the Pay-Khoy and North Ural at a height of 120 m. On the average the lowering of sea level could reach 70 to 100 m at the time, which coincides with indications by V. N. Saks for eastern segments of the Arctic. During the regression period, the coastal sections of the Barents Sea had the form of a strandflat plain which were intersected only by the valleys of great rivers (the Pechora and, probably, the Severnaya Dvina flowing from the neck of the White Sea, i.e. Gorlo Belogo Morya).

The rising of Barents Sea coast is of a differential type. The most energetic rising takes place on Novaya Zemlya and one may think that the rise of Novaya Zemlya is accompanied by subsidence in the trench at Novaya Zemlya (Prinovozemel'skii zhelob) and in the Pechora Depression. As is known, the subsidence of the latter began as early as in the Yurassic period and it was reflected in the accumulation of relatively thick layers of Mesozoic deposits. The subsidence is continuing at the present time. Geomorphological observations show that in the area of the Pechora coast the terraces are less clearly pronounced than in other coastal sections of the Barents Sea.

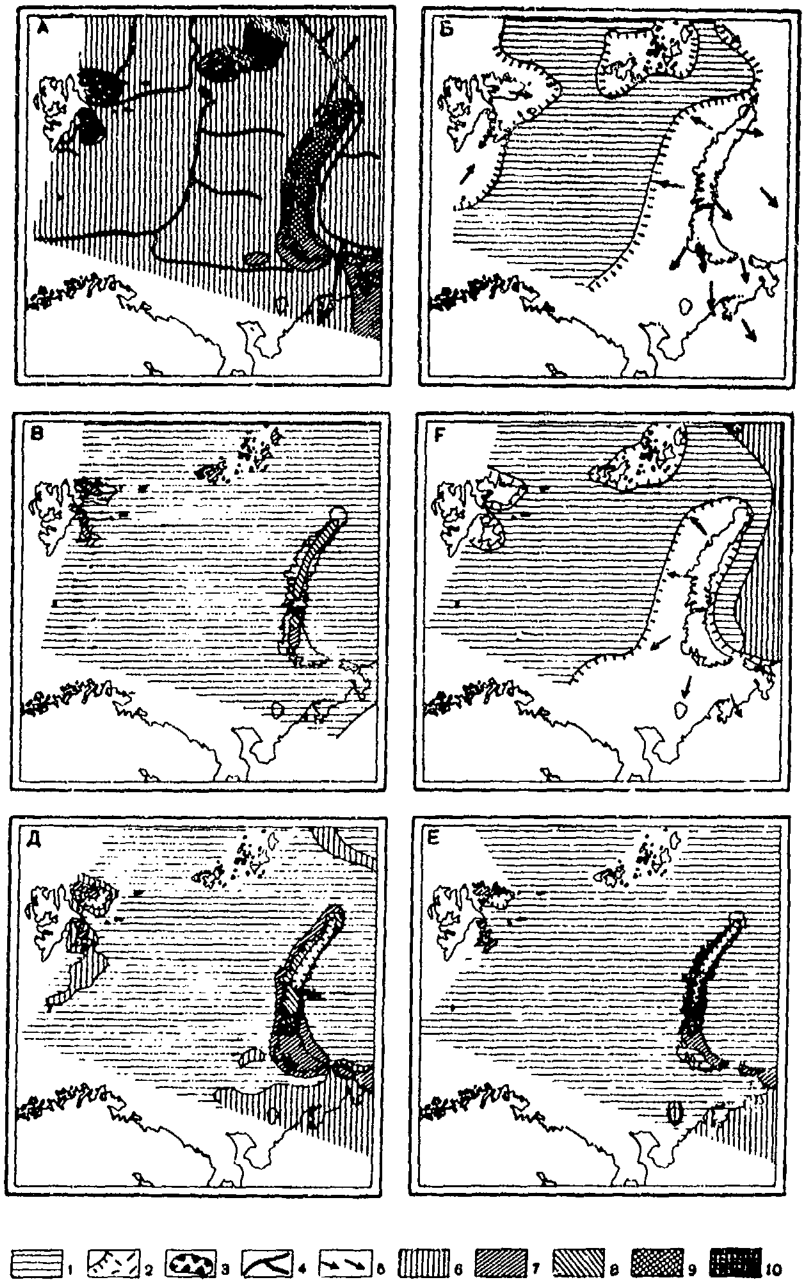

Fig. 19. Paleography of Barents Sea Area (according to V. N. Saks, 1948).

A--early Quaternary epoch, the time of greatest regression of the sea; Б--period of maximum glaciation; B--Sanchugov (interglacial) period; F--period of Zyryanian (Zyryanskoye) glaciation; Д--Sartanian (Sartanskoye) period; E--postglacial period; 1--water expanses; 2--ice caps or continental glaciers; 3--mountain-valley type glaciers; 4--rivers; 5--directions of ice movements; 6--plains; 7--low plateaus; 8--high plateaus; 9--mountains of medium height; 10--high mountain relief.

This is suggested by consolidation of material with depth in columns (Ia. V. Samoilov and M. V. Klenova, 1927), as well as by the intensive erosion of K lguyev Island (ostrov Kolguyev) and the disappearance of other islands that had existed here, evidently, not so long ago. In analogy with the more eastern areas, the erosion and destruction of islands is sometimes thought to result from the melting of permafrost. This of course does take place; however, the sea actions with respect to the transfer of products created by thermal abrasion would not have assumed such an intensity, if a slow sinking of bottom did not occur.

Evidently, the Western Trench, adjacent to the slope of Greenland Sea, the Norwegian Trench and the entire northern section of the Barents Sea, where numerous fractures have created a complex pattern of depressions and elevations, as well as the straits of Franz Josef Land, must be considered as sinking areas.

The problem of contemporary movements occurring on the Barents Sea floor will be re-examined after the discussion of morphologic areas of the floor and the elucidation of thickness and stratification of contemporary sediments.

Chapter IV

INVESTIGATIONS OF BARENTS SEA SEDIMENTS

The investigation of sediments in the Barents Sea, as well as in other polar seas, can be divided into two periods - very unequal as regards the quantity of material and the quality of its collection and processing.

The first period ending before World War I, 1914-1918, is characterized by individual information as to the type of bottom, which was scattered through the records of expeditions, fragmental special collections and laboratory analyses of collected samples; the number of the latter investigations which were carried out mainly by foreign expeditions was small, the methods of processing the material were different and the results of investigations could not be well compared.

The second period of investigations of the Barents Sea sediments began in the Soviet period. Oceanographic work on a large scale, utilization of the Northern Sea Route, the development of fishing, mainly trawling in the Barents Sea, raised new, great practical and theoretical problems concerning the studies of sea floor and made possible the collection of a large variety of material.

Most of the material was collected and processed by a single method worked out and tested prior to systematic studies (M. V. Klenova, 1926) and later coordinated with the organizations concerned and introduced for wide application (Instructions in Marine Geology, 1933). This made

possible the comparison of results and the utilization of collections made by various persons or expeditions, in various years and processed by various analysers.

The oldest data with respect to the Barents Sea floor are found on navigational charts and in sailing directions. Undoubtedly, the seamen furrowing the Barents Sea in sailing vessels calling on Grumant (Spitsbergen), Novaya Zemlya, Vaygach and Kolguyev knew the sea floor at anchor locations.

F. Litke (1828), who pointed out the need for bottom investigations "in icy seas" where " a circumstance skipped without use or ignored may cause irreparable damage....", does not forget to mention the type of bottom in his hydrographic studies dealing with the Murman coastal belt (Murmanskiy bereg) (at Lapland). Some of his remarks have been preserved in successive issues of sea charts up to the time of Soviet productions.

Indications as to the type of bottom are also found in the charts of British Admiralty, in German fishing maps, etc.

One of the first expeditions that collected and investigated the present deposits in Arctic seas was the Norwegian North Atlantic Expedition of 1876-1878. The samples of the expedition collected mainly in the Green- /104
land Sea and only a few in the western portion of the Barents Sea were analyzed by L. Schmelck (1882).

In his study L. Schmelck lists stations with typical sediments. The classification represents mainly the samples of individual forms of

rhizopoda, chemical analyses determining the composition of sediments which are soluble and insoluble in salt water, the calcium carbonate, ferric oxide and ferrous oxide content. The ratios of various ferric and ferrous oxides are computed by types of sediments in connection with their color, presenting a chart showing rhabdolith clay in the southern portion of the Barents Sea and the grey clay along the continental shelf of the Greenland Sea, the intermediate clay, biloculina (globigerina form) clay and volcanic sediments in the same sea. It follows from the description of samples that in the western part of the sea the layer of greenish-gray rhabdolith clay is very thin and is underlain by a grey clay.

A limited number of data concerning the sediments of the Barents Sea are included in the works of Ia. V. Samoilov and A. G. Titov (1917), as well as in the study of T. I. Gorshkova (1924). Thus began the investigation of contemporary marine deposits, which, initiated by I. I. Mesiatsev (Mesyatsev, 1921), was carried out at the Marine Scientific Institute. The studies laid the groundwork for systematic investigations of geology of the Barents Sea and the development of a new branch of science - marine geology. Later they led to the establishment of laboratories of marine geology: GOING, VNIRO and the new GOIN.

We shall discuss the development of investigation of the Barents Sea sediments in chronological order, touching only occasionally the studies devoted to the coast of the sea without discussing questions of methods which will be elucidated later.

In 1924 Ia. V. Samoilov and T. I. Gorshkova completed the investigation of sediments of the Barents and Kara seas on the basis of materials collected by the first expedition of the Floating Marine Scientific Institute in 1921 at Malygin. The samples were taken by a dredge and a trawl and at several stations by the Bachman Core. Fifty samples were subject to mechanical analysis by the Thoulet method, a number of samples were analysed from mineralogical and from chemical point of view; also a thorough review of literature was given.

In 1924, according to K. M. Deriugin's review (1924) of hydrological and biological studies conducted by the Northern Scientific Trade Expedition along the Kola Meridian, the bottom samples were examined at 12 stations and, besides, two mechanical analyses were carried out.

Since 1923 bottom samples were collected by T. I. Gorshkova, since 1925 by her and by M. V. Klenova and later by others during the oceanographic cruises of the survey vessel Persei (Persey).

The studies by Ia. V. Samoilova (posthumous, 1927) and M. V. Klenova includes the results of investigations of bottom cores obtained in 1923-1924 by the Persei (Persey). It presents mechanical analysis; further, after a special methodological study, a method of elutriation by controlling the size of grain with the aid of microscope (a transformed Osborn method) was utilized. A detailed description of samples and, for several stations, mineralogical analysis with a quantitative account of minerals in heavy and light fractions were carried out. Disclosed was an increase in the amount of minute fractions (less than 0.01 mm) with

depth in the sea floor in most of the cores examined, which is supposedly associated with movements of the coast line.

In a study, M. V. Klenova (1927) discusses a process of underwater weathering of rocks with the formation of ferrous layers, coatings and films, which were observed by the expedition on the Persei in 1926. The materials of an expedition conducted in 1927 include (M. V. Klenova, 1927) boulders found to the east of Mys Zhelaniya in the Kara Sea but which originally had been in the Barents Sea.

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In 1925 a British expedition in a steam ship commanded by F. Worsley (1927) carried out studies in the northwestern portion of the Barents Sea - namely, in the areas of King Charles Islands (Kong Karls Land), Northeastern Land of Spitsbergen (Nordaustlandet) and Franz Josef Land. The bottom samples were taken by the usual sea gauge and, in addition, boulders were collected from the sea floor during dredging. Further, 65 depth measurements were made. Ch. Bisset (1930), describing the collections of the expedition, lists the mean depths for the bottom types singled out by him: 51.5 nautical fathoms for a rocky bottom, 95 fathoms for "the blue mud (including the green, gray...)"; 130 fathoms for "the red mud (including the pink and yellow)"; and 142 fathoms for the samples consisting of two layers with "the red mud" covering "the blue one". When describing the stone material, he points out that the fragments of rocks are frequently covered with a brown coating of various thickness, the degree of its development depending upon the time of submergence and the size of nucleus of the rock. He also mentions data

relative to the content of ferric oxide and ferrous oxide in the coating and nucleus of the rock and in samples having various colors. The formation of the oxidized coating and the pink layer is ascribed by Bisset to the oxidizing action of sea water.

In 1930 M. V. Klenova has discussed the sand of Chëshskaya Guba (fig. 28) whose samples were collected by the author of expedition on the Persei (Persey) in 1926, carried out mechanical analyses,designed sediment charts and made a conclusion that Chëshskaya Guba is a gulf of the ingression type where an intensive washout of former marine sediments takes place at the present time.

In her transactions (1930) on geological studies of the Marine Scientific Institute for the III All-Union Geological Congress in 1928, M. V. Klenova presents the distribution of sediments on the basis of color of the upper layer, pointing out that, in accordance with special analyses carried out for the same samples, the difference in the composition of the upper pink layer and of the lower greenish-gray layer can be explained by different oxidation degrees of iron.

The transactions by T. I. Gorshkova (1930) outlines the results of chemical-mineralogical investigations of sediments of the Barents and White seas (1931). Some of the conclusions and data of the work will be elucidated below.

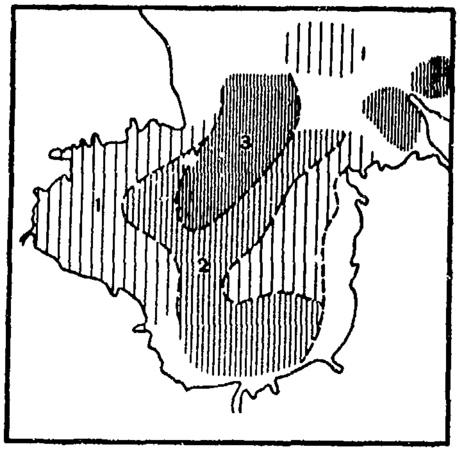

Fig. 28. Distribution of Sand in Chéshskaya Guba (according to M. V. Klenova, 1930).

1 -- coarse sand;

2 -- medium sand;

3 -- fine sand.

In 1931 was completed the preparation of commercial bottom charts for individual areas of the Barents Sea. The transactions by M. V. Klenova (1933) for the first session of the State Oceanographic Institute in April 1931 expound the investigations of mechanical composition of sediments and the statistical processing of about 60 thousand bottom identifications on the basis of data collected by the captains of commercial trawlers during 1927-1929. The bottom charts and lithological profiles enabled us to notice a number of characteristics in the distribution of sediments on the sea floor, which were confirmed also by later studies. Thus, it was established that a variation in mechanical composition occurs when the change in depth reaches 5 to 10 m if the angle of slope is small. The angles of slopes were investigated, the submerged coastal contours were disclosed at a depth of 180 to 220 m and 50 to 70 /106
m; also accumulations of commercial fishes were found at these depths.

M. V. Klenova (1932) prepared sediment charts for the northwestern portion of the Barents Sea, which were based on mechanical analyses of samples collected in 1930 from the vessel Knipovich in the areas of Charles Island (Prins Karls Forland), Victoria Island (ostrov Viktoriya), the White Island (Djevleøya or ostrov Belyy) and Franz Josef Land. The investigations of sediments in the area, which are frequently covered with ice, enabled us to classify the distribution of sediments on the sea floor by mechanical composition and by ice distribution on the sea surface. When comparing the character of sediments with iciness we succeeded in finding that, if all other conditions are equal, a greater chance to come across concentrated ice in calm areas characterized by

sedimentation of a material with mud greatly in preponderance than in areas characterized by swift water movement, where relatively coarser sediments are deposited.

On the basis of experiences from preceding investigations, instructions in marine geology (1933) were prepared in 1932, but in 1933 a number of studies of the Motovski Gulf (Motovskiy Zaliv) and of many sea arms of the Murman Coast (Murmanskiy bereg) and the White Sea (Beloye More) were completed (M. V. Klenova, T. I. Gorshkova, L. A. Iastrebova, V. P. Zenkovich, 1938). M. V. Klenova presented an analysis of bottom relief in the Motovski Gulf (Motovskiy Zaliv), the distribution of sediments, their characteristics according to mechanical composition, the content of heavy fractions, mineralogical analyses of a number of samples, the distribution of boulders, the relation of ferrous oxide and ferric oxide. All of the data are related to the general hydrological, hydrochemical and biological regime of the gulf.

T. I. Gorshkova (1938) investigated the content of organic carbon and nitrogen, finding that in the sediments of the Motovski Gulf (Motovskiy Zaliv), as well as in those of the Barents Sea (1936), the quantity of C and N is associated with the content of fractions smaller than 0.01 mm and that it increases with increase in their quantity. The ratio of carbon to nitrogen is rather constant, the average being 7.

The investigation of chlorophyll (1938) enabled L. A. Iastrebova to find that it is completely absent from the pink sediments of the Barents Sea, which can be explained by their great oxidizing ability.

The investigations carried out in the Motovski Gulf (Motovskiy Zaliv) in 1931 and in the sea arms of the Murman Coast (Murmanskiy bereg) and the White Sea (Beloye More) initiated a systematic bottom survey of Murman fjords as a result of which a number of bottom charts and explanatory notes were prepared (V. P. Zenkovich, P. S. Vinogradova, L. A. Iastrebova et al). Here it is not possible for us to discuss the studies because of lack of space, though they present a vast material for learning the general rules of sedimentation and the factual information of distribution of bottom types in connection with the relief of the many gulfs and sea arms.

In 1934, when the Marine Scientific Institute was included in the system of fisheries, the research of marine geology based on the methods developed for the Barents Sea was transferred to other seas of USSR. Laboratories concentrating on bottom surveys and on systematic investigation of coasts were organized.

In 1934 T. I. Gorshkova (1957) completed her work on the distribution of carbonates and organic substances in the sediments of the Barents Sea the results of which will be discussed more thoroughly in the chapter dealing with chemical processes. In the same year M. V. Klenova presented for the first time a chart of the entire sea showing the distribution of fractions smaller than 0.01 mm, the mean mechanical composition of various types of sediments and chemical analyses of the types (1940).[1] In the ensuing years there appeared a number of articles dealing with individual problems of sediments in the Barents Sea. The problems will be discussed in the respective chapters of this book.

[1] A condensed version of the work was published in 1940.

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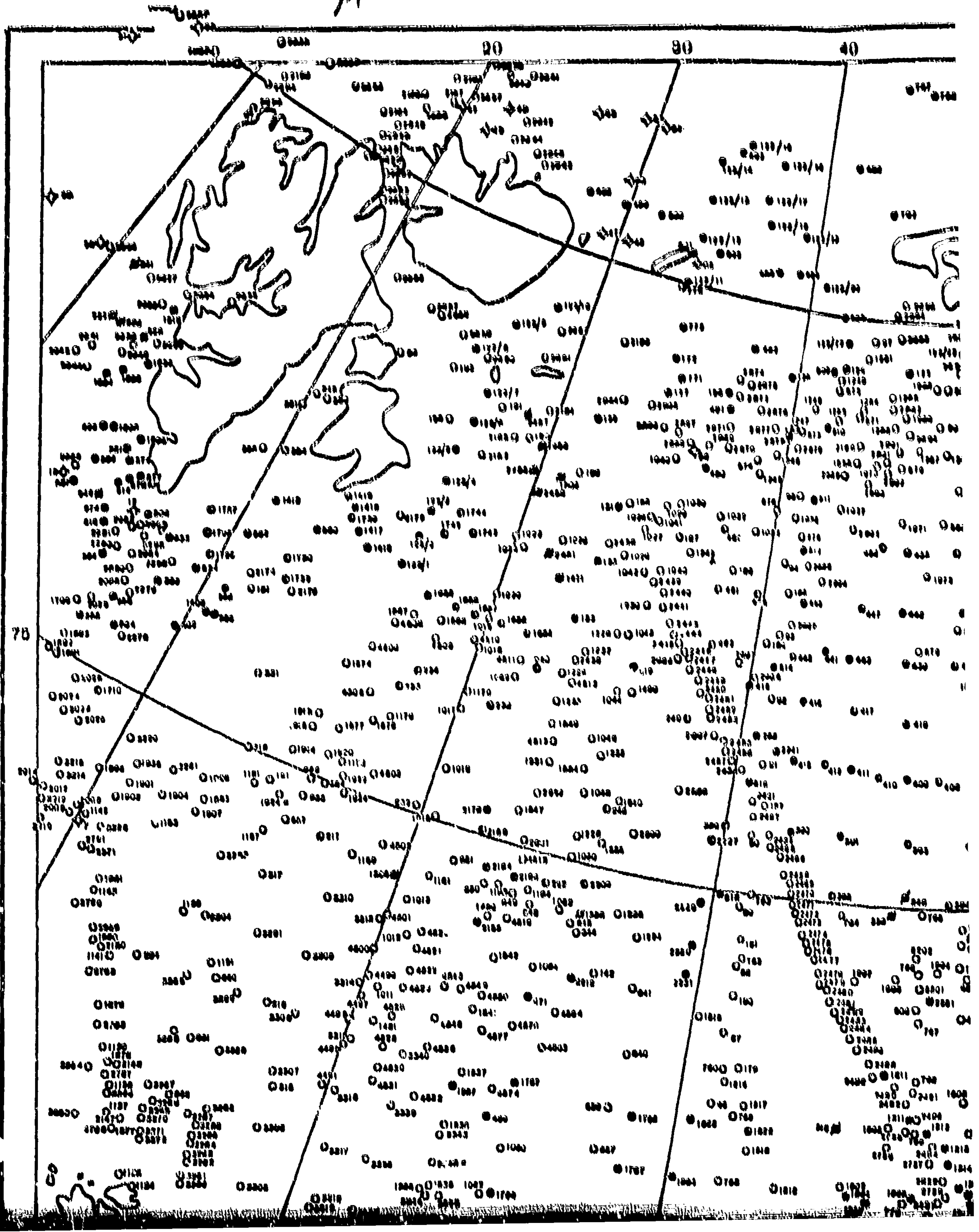

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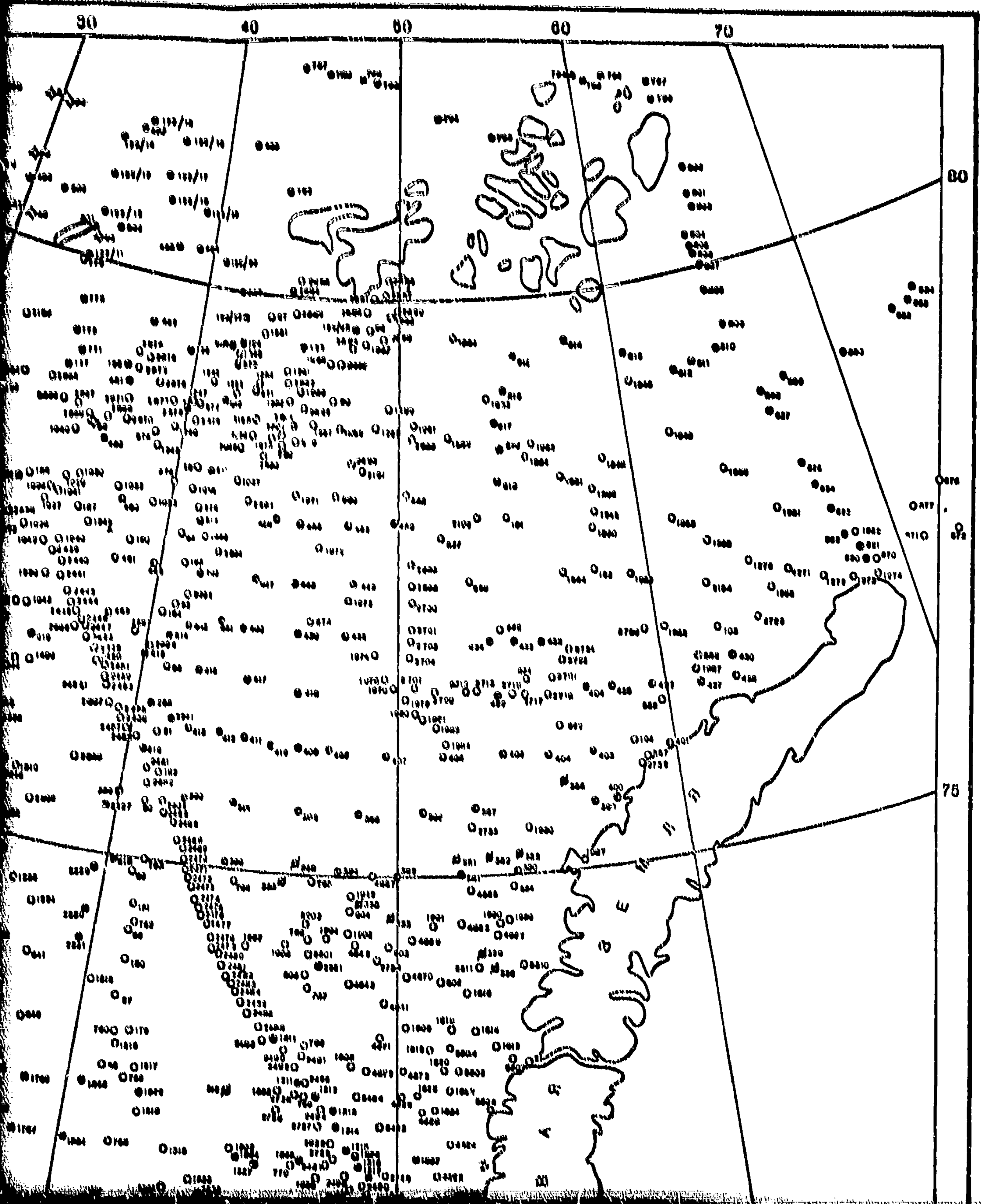

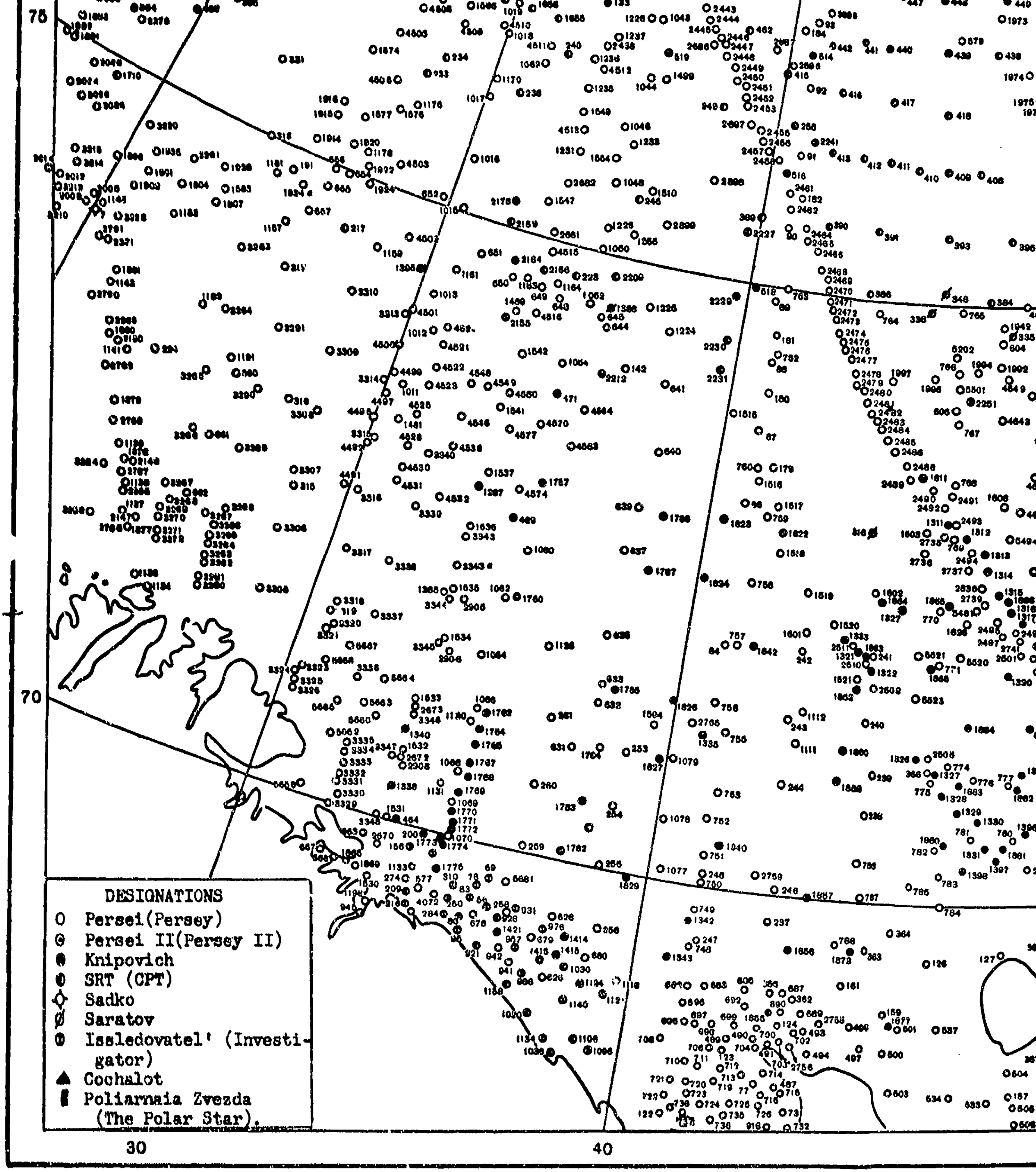

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Fig. 29. Chart of Stations.

C

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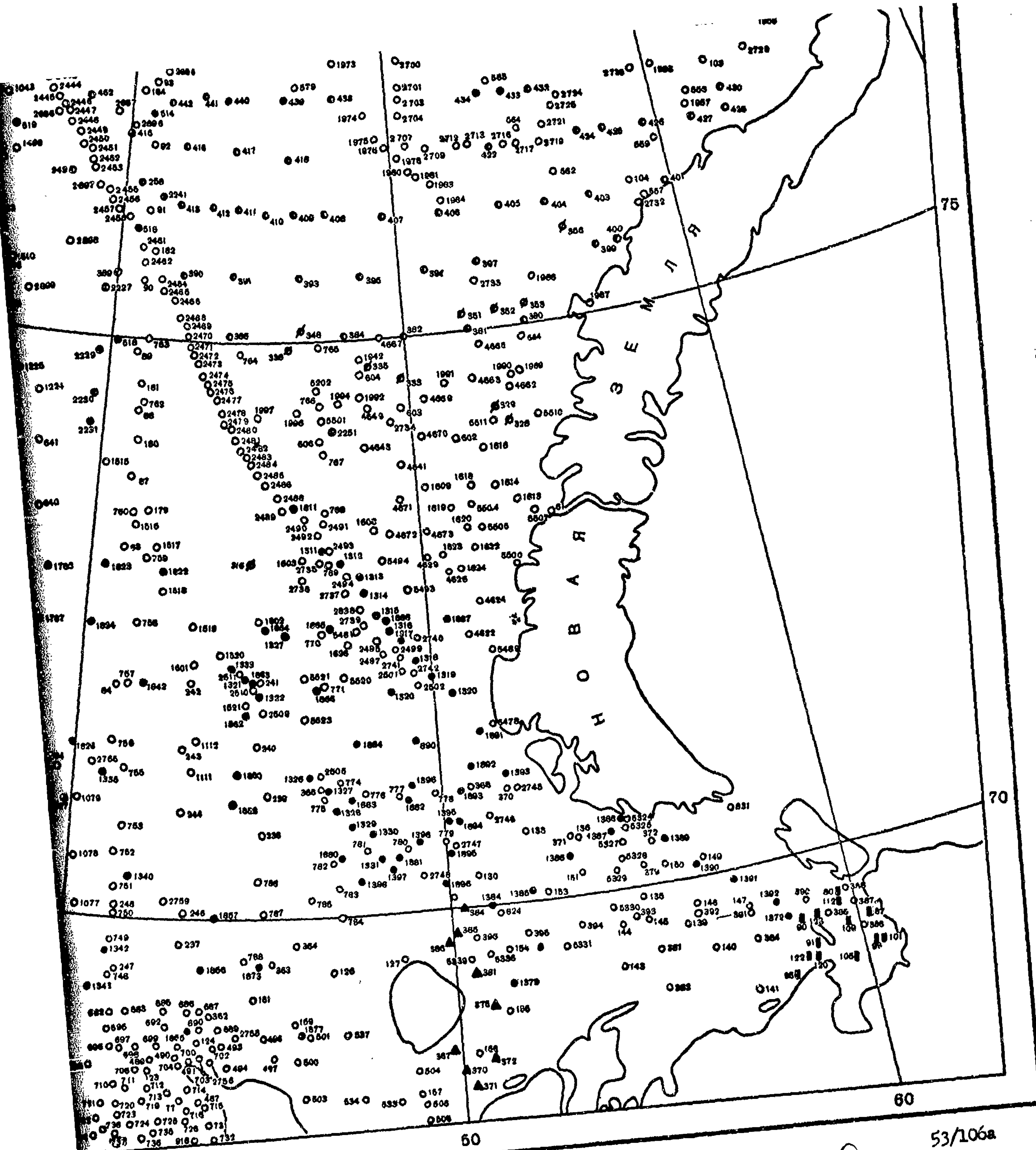

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Fig. 29. Chart of Stations.

Further, the conditions of underwater weathering were clarified (M. V. Klenova, 1936), the distribution of manganese (M. V. Klenova and A. S. Pakhomova, 1940), phosphorus (M. V. Klenova and M. L. Budianskaia, 1940), chlorophyll (V. P. Zenkovich and L. A. Iastrebova, 1946) were investigated. Several cores of the Barents Sea were described (P. S. Vinogradova, 1946), the oxidizing-reducing regime and p H were studied (S. V. Bruevich, 1938; A. V. Trofimov, 1939). Also the results of investigations of coasts were published (V. P. Zenkovich, 1937, 1938, 1941, etc.; D. G. Panov, 1941 etc.) as well as those of bottom morphology (M. V. Klenova, 1938, 1939; V. P. Zenovich, 1938).

Simultaneously, the scientific-commercial investigations of the sea bottom and comparison of charts continued (P. S. Vinogradova, V. P. Zenkovich, O. N. Kiselev, M. V. Klenova and others) as well as laboratory investigations of the many collections which were used as a material for this study (fig. 29).

Before discussing the factual material, the methods used by various investigators in studying the sediments of the Barents Sea must be outlined. The need for using a well-defined method in order to obtain comparable materials have been mentioned more than once (Ia. V. Samoilov, 1926; M. V. Klenova, 1931, 1934, 1936). It is known that any retreat from one or the other method of sample collection or the preliminary processing and laboratory research of such complex and unstable material, as the marine sediments are, cause deviations in numerical results.[1]

[1] The possibility of direct numerical comparisons was of special importance in the first stage of investigations concerning the marine sedimentation.

First of all, attention should be paid to the method of collection and preservation of samples. In the Norwegian expedition during 1876-1878, the bottom samples were obtained by a tubular gauge, the length of the tube being 9 inches and width 2 inches at small depths; but at depths greater than 1000 fathoms a longer tube was used (17 and 2.2 inches, respectively). After removal and a brief description of samples, they were placed in glass jars and delivered to laboratory. On the Fram also the samples were collected by a tubular gauge; they were kept either in alcohol or in dry condition. On the Belgic the samples were collected by a bottom dredge (draga) and the samples left for processing in Thule were fixed with formalin in glass jars.[1]

[1]As is known, formalin dissolves calcium carbonates and is used in contemporary oceanographic research only for fixing the organisms not containing carbonates.

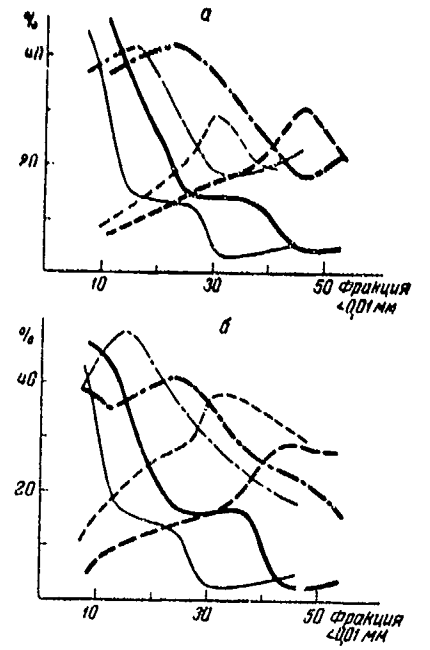

Fig. 30. The mean mechanical composition of sediments of the Barents Sea for moist and dry material (according to V. P. Zenkovich, 1949).

Key. Fig. a: x-axis - fractions <0.01 mm
Fig. б: x-axis - fractions <0.01 mm

— 1 — 2 — . — 3 —·— 4 — — 5
— — — 6

a--groups of fractions smaller than 0.01 mm in a dry material; б--groups of fractions smaller than 0.01 mm in a dry and a moist material, respectively; 1--fractions 1-0.1 mm in diameter on the basis of analysis of a moist material; 2--the same on the basis of analysis of a dry material; 3--fractions 0.1-0.05 mm in diameter on the basis of analysis of a moist material; 4--the same on the basis of analysis of a dry material; 5--fractions 0.05-0.01 mm in diameter on the basis of analysis of a moist material; 6--the same on the basis of analysis of a dry material.

On the Poseidon Expedition the bottom was characterized by samples taken by dredges. Dr. Alburg and Dr. Stoller studied samples taken by dredges; only 10 samples were obtained by tubes.

Thus, prior to the Soviet research, the improved instruments for the collection of bottom samples, which were already known and applied in oceanographic research on the Challenger, Baldwin, etc., were almost never used in the Barents Sea.

The samples of Plovmornin Expedition on the Malygin in 1921 were also taken mainly by dredges and trawls; only 15 samples out of the number processed by I. V. Samoilov and T. I. Gorshkova (1924) were taken by the Bachman tube. The samples were fixed by spirit.

In 1923-1924 the expedition on the Persei (Persey) utilized the Bachman and Eckman tubes. The coefficient of useful action of the former was 46%, of the latter 61%. The average length of tubes was 6,7 and 17 cm, respectively. In 1925 the use of improved types of Eckman tubes was introduced on the Persei (Persey). The tubes were equipped with an internal bearing, which made possible the collection of samples in natural conditions without deformations, with conical valves and strainers that slide down the tube and close its lower end as soon as the tube leaves the bottom; as a result, the coefficient of useful action increased to 76%.

In cruises during 1923-1924 the fixing of samples was done by spirit. Since 1925 they were preserved in dry conditions; the fixing with spirit

was done only for investigation of rhizopoda.

After 1928, some samples and those processed by the writer of the monograph dealing with the methods of research were taken in moist natural conditions.

As has been pointed out several times [Ia. V. Samoilov, 1926; K. N. Deriugin, 1928; II All-Union Hydrological Congress; III All-Union Geological Congress in 1928 in Tashkent (resolution on report by M. V. Klenova, 1930); IV Hydrological Conference of Baltic Lands in Leningrad, 1933; M. V. Klenova, 1934, 1948] a great difference exists in methodological problems of mechanical analysis, which is the first step in the investigation of loose materials, soils and rocks. Several attempts to achieve a uniformity of methods, which have been made at a number of conferences, at international conferences of soil scientists for instance, and elsewhere, have not yet led to a generally approved standard method and classification of fractions. Even the investigations of samples collected by the same expedition are made by various methods and limits of fractions, which leads to incomparable data (Prattje and Correns, for instance, when processing the results of German expedition on the Metheor in 1925-1927).

Also for the investigation of sediments of the Barents Sea and the adjacent basins most diverse methods were used. Thus, O. Bøggild (1906) used the Schene method for the samples collected by the expeditions on Ingolf and Fram, Thoulet (1910) employed the screen analysis for course

fractions and elutriation in a separating funnel for minute fractions. Stetson (1933) employed the screen and hydrometric methods, as established by Casagrande, for the examination of samples obtained by the expedition on Nautilus. With a view to obtaining a material comparable with the data obtained by Thoulet, Ia. V. Samoilov and T. I. Gorshkova (1924) processed the samples brought by the Malygin in 1921 by elutriation in a separating funnel. Soon Ia. V. Samoilov (1923) paid attention to the existing divergence in the problems of mechanical analysis and classification fragments, organizing methodological studies in finding most complete methods and a uniform classification system. After Ia. V. Samoilov's death in 1925, this work was completed by the writer of this monograph (1926, 1930, 1931). The method of mechanical analysis controlling the size of grain by means of a microscope was established by the Interdepartmental Commission on Mechanical Analysis at the State Oceanographic Institute, which approved also the classification of /109
fragments and classification of sediments concerning the mechanical composition, which were proposed by the writer. The moistening of bottom (samples) batches, which had been dried at room temperature and kept in air-dry condition, was approved as a method for preparing samples for analysis.

According to the decision of the commission (M. V. Klenova, 1931), a standard method and classification was approved (in 1930) by the Hydrographic Administration for the investigation of sediments in the Barents Sea and later for other seas. Further, the standard method and classification were approved for use on sea charts: for bottom charts in 1940

and for the charts of Sea Atlas (Morskoy Atlas) in 1944.

The investigational method of mechanical composition of sediments was widely used in studies of bottom surveys for all the seas of USSR.

In 1935 V. P. Zenkovich carried out a methodical study of the materials collected from the Barents Sea with a view to clarifying the effect of drying on the mechanical composition of samples. As could be expected, and as was noted by K. Correns relative to the sediments of the Atlantic Ocean (1935), the results of analyzing moist and dry samples differed considerably. The difference increased with increase of fractions smaller than 0.01 mm (table 4).

According to data by V. P. Zenkovich (1949), the relation between the content of small fragments in moist and dry samples varies from 1.1 to 1.93.

The diagram of the mean mechanical composition (fig. 30 on page 107) computed on the basis of the data for dry and moist samples shows the displacement of curves characterizing individual fragments, while preserving the over-all pattern. Also the general pattern of the distribution of sediments on the bottom (fig. 31) is preserved. Thus the assertions of V. P. Zenkovich (1949) and S. I. Malinin (1951, 1954) that a sample assumes an essentially different mechanical composition of drying, which is artificially changed in the process of analysis, cannot be substantiated.

Table 4

MECHANICAL ANALYSIS OF BARENTS SEA SEDIMENTS AT VARIOUS METHODS OF PREPARATION (ANALYSES BY P. S. VINOGRADOVA AND S. I. MALININ)

Fraction, mm	St. 3288		St. 3225		St. 3313	
	Weight, g					
	6.0	19.78[1]	5.93	18.05[2]	6.8	14.36[3]
	a	b	a	b	a	b
>1	(4.0)	(8.0)	(26.5)	(34.0)[4]	Traces	Traces
1 - 0.1	58.1	59.7	27.1	31.4	1.9	1.8
0.1-0.05	26.2	24.9	25.7	17.7	19.9	12.5
0.05-0.01	8.4	5.2	23.2	17.4	42.2	33.0
<0.01	7.3	10.2	24.0	33.5	36.0	52.7

Key. a designates dry material;

b moist material.

[1,2,3] St. 3288: muddy sand, moisture 26.08%; St. 3225: sandy mud, moisture 42.9%; St. 3313: mud, moisture 53.9%.

[4] Fraction >1 mm is deducted from the batch and is not included in the sum of 100%.

Numerous simultaneous and repeated analyses of Barents Sea sediments processed by elutriation, controlling the grain size, demonstrated that differences between simultaneous analyses of (1) fragments smaller than 0.01 mm do not exceed 1.1%; of (2) coarse silt particles (from 0.1 to /110
0.05 mm) do not exceed 3.5%; of (3) minute silt particles (from 0.05 to 0.01 mm) do not exceed 2.9%; and of (4) sand (from 1 to 0.1 mm) do not exceed 3%. Differences in gravel, whose quantity is deducted from the batch, are considerably greater because of size of the batch is small - 5 to 8 g, but for determination of the amount of coarser material, considerably greater batches - to 100 g and more - are needed (M. V. Klenova, 1930).

For fragments smaller than 0.01 mm the agreement among calculations made by various analysers is the best, but the average differences for calculations made by various analysers exceed the differences among the calculations made by the same analyser, which has already been mentioned (M. V. Klenova, 1930).

The analyses of core and dredge samples taken at the same station, as could be expected, yielded less constant results. This can be explained by the fact that only the upper layer of a column can be secured without destroying the stratification, but in the case of a bottom dredge one can obtain undisturbed composition of the upper layer only under very favorable conditions, if it is possible to cut out a section without disturbing its stratification and if the upper layer is not washed out when the instrument is lifted on ship board.

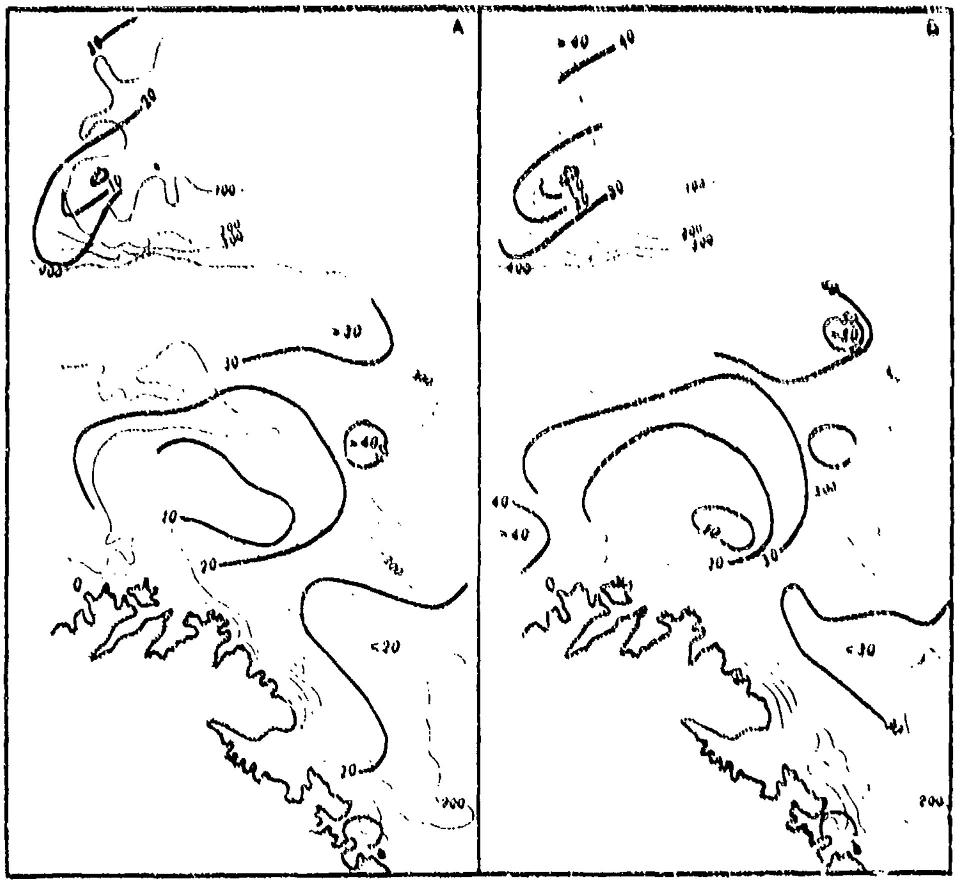

Fig. 31. Isolines of the content of fragments smaller than 0.01 mm (in percentages) for an area of the Barents Sea based on dry and moist materials (data by V. P. Zenkovich).

A -- based on analysis of dry material;

Б -- based on analysis of moist material.

Certain differences may occur also due to the displacement of the point at which the respective sample has been taken; the displacement is caused by the drifting of ship, which takes place even when repeated sample columns are taken by bottom corers. These instances are specifically mentioned below when the areas are described because they occur mainly on steep slopes and indicate rapid shifts of bottom types when the ship is drifting.

The samples collected by bottom corers and dredges enable us in a majority of cases to compare bottom types even if differences occur in the quantity of fragments.

The listed data and numerous analyses made for the sake of controls and verification demonstrate that the numerical results of analyses that have been carried out in the right way are characterised by a sufficient constancy and therefore they can be utilised for the clarification of distribution patterns of sediments on the bottom.

As we shall later see, the mechanical composition of sediments varies regularly in connection with relief and hydrodynamic regime. Thus, there is no ground for asserting that an artificial product is analysed.

Chapter V

DISTRIBUTION OF SEDIMENTS IN CONNECTION WITH RELIEF

1. The Nordkapp Area

The Nordkapp (North Cape) area or the area of the Norwegian Trench is located in the southwestern part of the Barents Sea which adjoins Finnmarken (Finnmark), Varanger Peninsula (Varangerhalvøya) and Varangerfjord. As was mentioned before, the coast in this area is composed of sedimentary rocks contorted as a result of Caledonian and pre-Cambrian foldings. It is indented by great fjords - Tanafjord, Porsangerfjord, Laksefjord and a number of open gulfs. Along the coast, parallel to the area of the Fenno-Scandinavian (Fennoscandian) Shield, extends a trench having a northwesterly direction. Toward the north, the trench becomes a depression having irregular contours and to the west it is bounded by a sloping elevation of bottom in the Nordkapp traverse. The southern slope of the trench is steep, reaching to a depth of 400 m and more. The overall gradient of the bottom in the Nordkapp area is 2°30'. The bottom of the trench is undulating.

A large stream of Atlantic water enters the Barents Sea through the Norwegian Trench (the Nordkapp branch of the Gulf Stream). The northeast exposure of the coastal line, which is normal to the greatest dimension of the Barents Sea, leads to an intense wave erosion under the action of northerly winds. The sediment distribution on bottom is

dependent upon an active hydrodynamic regime.

The bottom of the Nordkapp area is predominantly covered by a sandy mud which is replaced by muddy sand and a coarser material nearer to the coast.[1]

At the eastern end of the Norwegian Trench, where the turbulence of water is small, mud is being deposited. In connection with the bottom relief along the coast (fig. 32), the sediments consist of pebble, detritus (shcheben'), gravel; but near Nordkapp, even at a depth of 308 m (St. 1134), one can find a coarse shelly sand and fine gravel containing a large quantity of organic carbonate fragments among which the grains of minerals disappear. The lamina and spines of sea urchins, the remains of hydroids, sizable rhizopods, fragments of mollusks Pecten islandicus and brachiopods are found here. Single mineral nuclei are represented by quartz and fragments of rocks which are partly subangular. At lesser depths, slightly to the west, the bottom is covered by a shelly sand of yellowish-white color containing numerous calcareous rhizopods with a small admixture of sponge spicules (St. 2146, from 236 to 250 m). At the base of the slope one can find (St. 1135, 310 m) a light and fine

[1]The collection of bottom samples was made by the expedition ship Persei (Persey) during the following cruises: the 5th in 1924, the 17th in 1928, the 50th in 1934. - T. I. Gorshkova; the 19th in 1929. - K. R. Olevinskii; the 28th in 1930. - V. P. Zenkovich; the 35th in 1931. L. A. Iastrebova and E. K. Kopylova; the 40th in 1932. V. P. Zenkovich and E. K. Kopylova; 49th in 1934. P. N. Novikov; 54th in 1935. S. I. Malinin and Kuzovleva. On the expedition ship Knipovich during the 52nd cruise (in 1935) the collections were made by N. N. Khoklin.

greenish-gray sand with numerous fragments and unbroken Astrorhiza, Miliolina, Globigerina, spines of urchins and sponges, shells of ostracods, fragments of mollusks, etc. In the mineral fraction the angular quartz grains prevail; also the feldspar and mica are found. A large quantity of gravel and shingle, in a majority of cases rounded and subangular, derived from granite and gray schist (rod-shaped fragments) is in great quantities mixed with sand. Despite a certain decrease of depth (St. 2786, 290 m), farther to the north on the cross section one can find greenish-gray dust-like and muddy sand consisting predominantly of quartz and having an admixture of silicic spicules of sponges and, in smaller quantity, gravel, detritus and carbonate fragments.

The profiles (fig. 33) show that, with increasing distance from the coast and increasing depth, the quantity of coarse fractions decreases and the proportion of grains smaller than 0.01 mm increases. Sand turns into muddy sand and sandy mud, which becomes considerably coarser or is replaced by muddy sand again as the bottom rises (fig. 33, A). As the depth varies from 286 to 367 m the quantity of particles smaller than 0.01 mm increases from 6.3% (St. 3280) to 24.5% (St. 3284).

If hydrodynamic processes are active, a close connection between the composition of sediments and relief is observed even over very small distances. Thus, for instance, at the point 70°30' of the cross section extending along the Kola meridian, where, as a result of repeated hydrological investigations, we had obtained more than once samples consisting of yellowish-gray sandy mud underlain by old rosy-gray clay, the depths of stations established by individual cruises ranged from 241 to 252 m.

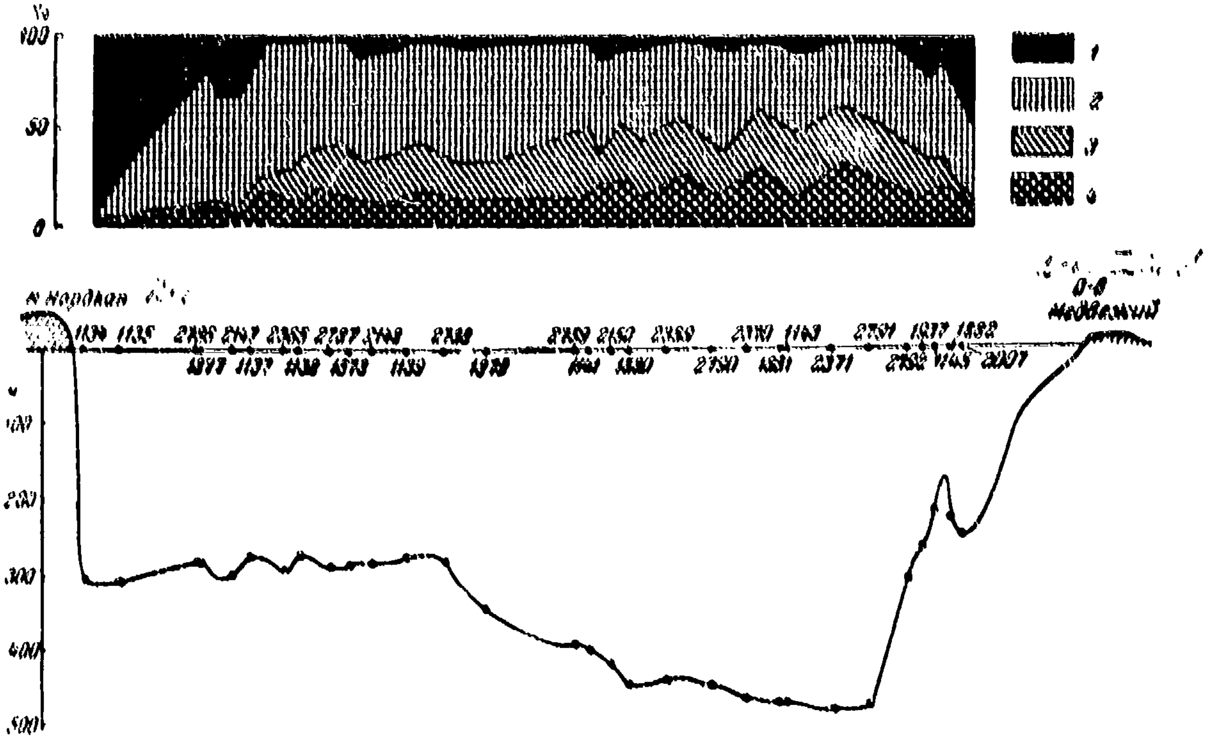

Fig. 32. Changes with depth in mechanical composition of sediments along the cross section Cape Nordkapp-Bear Island (Bjørnøya).

1 -- fragments from 1 to 0.1 mm;

2 -- fragments from 0.1 to 0.05 mm;

3 -- fragments from 0.05 to 0.01 mm;

4 -- fragments less than 0.01 mm.

Horizontal line: Cape Nordkapp ------ Bear Island.

Despite the fact that analyses were carried out by various analysts and at various times, they came up with the same type of sediment, in which the proportion of grains smaller than 0.01 mm changed with changes in depth. Also the changes in thickness of the upper layer are regular; the thickness increases with decrease in depth.

An old viscous clay, which, according to O. Holtedahl, is of morainic origin can be seen at places on the surface of the bottom or it is concealed by a thin layer of the contemporary deposits on steep slopes of continental coasts.

On the cross section extending along the Kola meridian, a rosy-gray clay is found under the layer of contemporary yellowish-gray sandy mud and has a thickness of 13 to 27 cm (St. 1532, 241 m; St. 2908, 248 m; St. 3347, 246 m; St. 1533, 223 m). At Station 1534 (261 m) the rough surface of a dense and heavy gray clay with gravel and few carbonate remnants is covered with a sandy interlayer over which a layer of greenish-gray sandy mud 17 cm thick is lying (fig. 34, 1).

At stations located more to the west (St. 2786, 290 m; St. 1877, 282 m) the underlying gray or rosy-gray sandy mud with few carbonate remnants, numerous sandy interlayers and sometimes with pseudomorphs of limonite /115
after pyrite, which changes gradually into the contemporary greenish-gray or yellowish-gray muddy sand with sponge spicules and carbonate rhizopods. Exactly the same gradual transition from gray and slightly rosy-gray mud to greenish-and yellowish-gray mud is observed in the calm zone of the eastern end of the Norwegian Trench at long. 35° E (St. 1070,

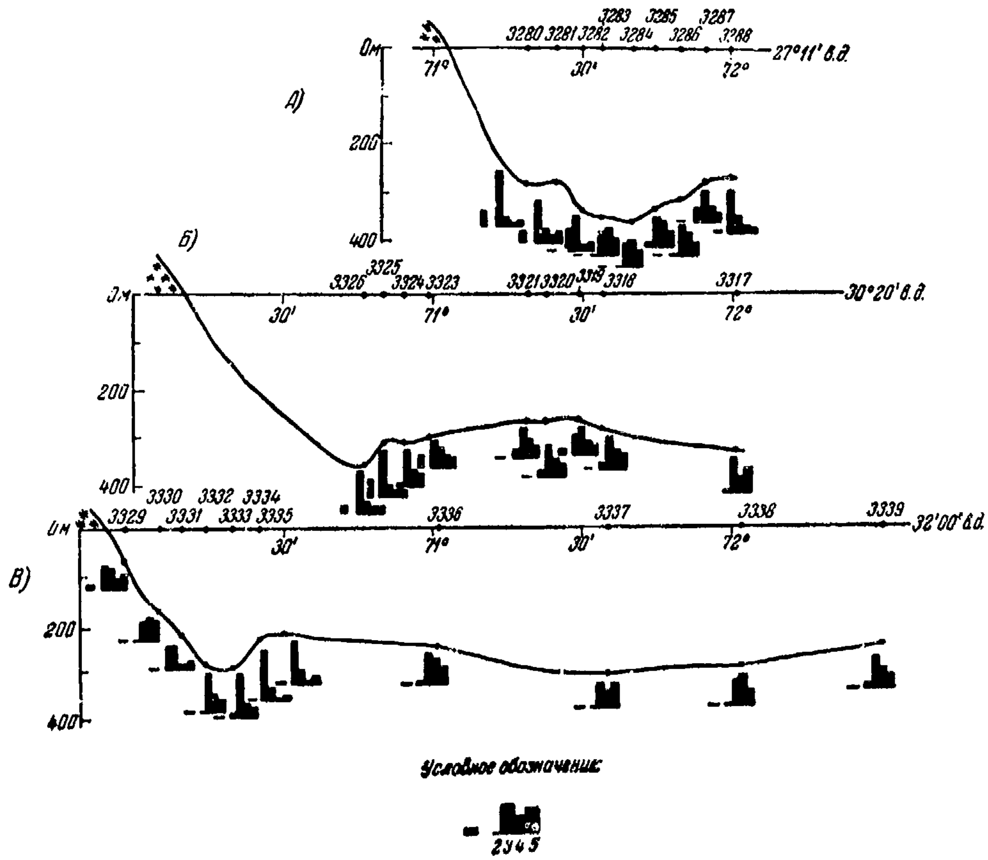

Fig. 33. Changes with depth in mechanical composition of sediments.

A -- cross section along the 27th meridian (Stations 3280 to 3286);

Б -- cross section along the 30th meridian (Stations 3317 to 3326);

B -- cross section along the 32nd meridian (Stations 3329 to 3339).

Fractions in histograms: 1--greater than 1 mm; 2--from 1 to 0.1 mm; 3--from 0.1 to 0.05 mm; 4--from 0.05 to 0.01 mm; 5--smaller than 0.01 mm.

Horizontal line beneath the figure: designations.

240 m) where, evidently, the accumulation of erosional products takes place. Along the northern boundary of the area, the thickness of contemporary sediments decreases to 7 cm (St. 3337, 313 m) and to 1 to 2 cm (St. 3339, 267 m). Deeper, beneath the underlying layer of old clay, a transition layer consisting of a mixture of greenish-gray sandy mud with lumps of dense homogenous gray clay is found. Analysis of surface layers of the columns, as in the case of St. 1070, leads to a double-apex graph of mechanical composition (fig. 33, Б, St. 3317; fig. 33, B, St. 3337).

Thus the slopes of the Nordkapp Trench can be characterized as areas having a thin layer of sediments covering the underlying deposits of greater age which is either marked by a pronounced boundary or by a transitional layer of mixed composition.

Thus the slopes of the Nordkapp Trench can be considered as areas covered by a thin layer of contemporary deposits lying on older deposits; the boundary is either sharply delineated or an intermediate layer of mixed composition lies between the two layers.

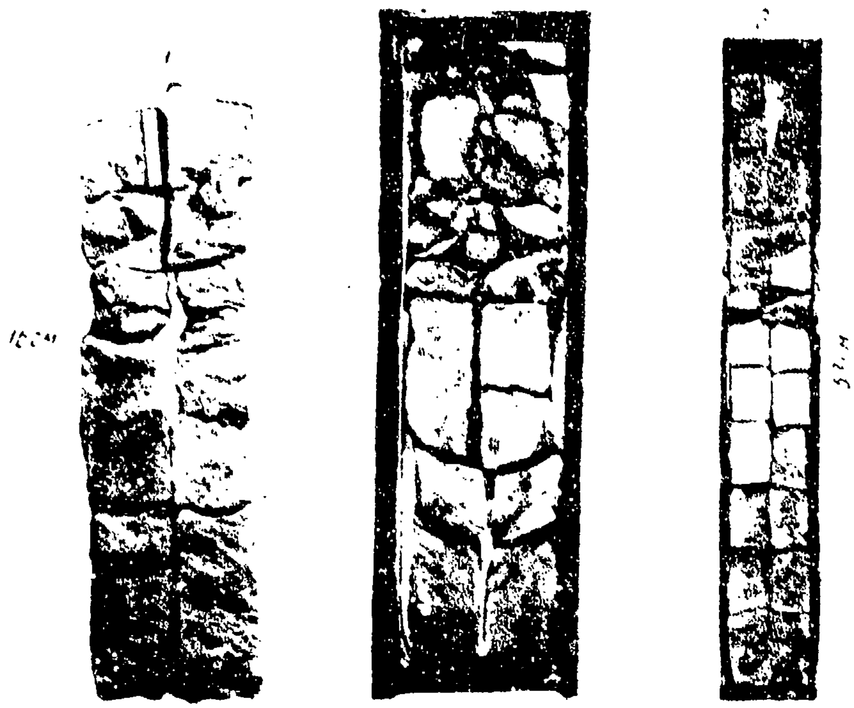

Fig. 34.

1 -- sandy interlayer with gravel on a rough surface of rosy-gray mud (clay) on a 16 cm column beneath greenish-gray sandy mud-the second column of St. 1534, 261 m;

2 -- old clay, rosy-gray and bluish-gray, under the present greenish-gray sand with gravel (St. 677, 143 m; the length of column 30 cm);

3 -- the same under sandy mud (St. 673, 219 m; the length of column 53 cm).

The swift currents and steep gradients characterize well the presence of coarse deposits at great depths. Although in connection with a profuse development of bottom fauna, which is associated with the inflow of warm Atlantic waters, an essential part of the coarse fragments of deposits consists of remnants of organisms, the fact does not modify the basic rule of sedimentation, i.e. a close connection between the variation of mechanical composition and the bottom relief as well as the hydrodynamical regime.

With increase in the quantity of fragments smaller than 0.01 mm the content of sand particles decreases. A curve in the interval of muddy sand attests that a considerable quantity of material comes from another source. In this case it is determined by an increase in the proportion of particles of this size (muddy sand) on the steep slope between the coast and the depths of the Norwegian Trench. Also the coarse silt fraction increases here, but the bend of the curve of fine silt indicates an increased content of clay aggregates in some products of the erosion of old sediments.

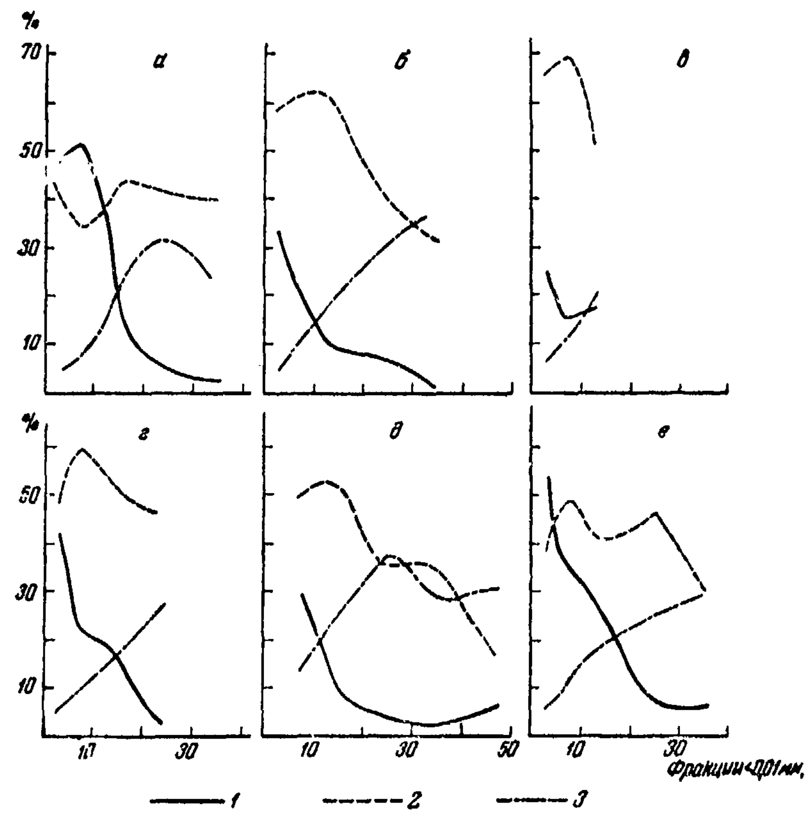

Fig. 35. The mean mechanical composition of sediments in the southern part of the Barents Sea where the hydrodynamic activity is great.

a -- the first (Nordkapp) area; б -- the second area (Murmanskoye melovod'ye); в -- the third (Prikaninskiy rayon) area; г -- the fifth area (Murmanskaya banka); д -- the sixth area (Zapadnyye promyslovyye banki); e -- the eighth area (Gusinaya banka or Goose Bank). Fragments in mm: 1 -- 1.0 to 0.1; 2 -- 0.1 to 0.05; 3 -- 0.05 to 0.01.

Table 5

MEAN MECHANICAL COMPOSITION OF SEDIMENTS

Type of bottom	Fractions <0.01 mm in %	Depth in m, from-to	Depth in m, mean	Fractions in mm >1	1-0.1	0.1-0.05	0.05-0.01	<0.01	Number of analyses
Nordkapp Area									
Sand	<5	307-310	308	(7,0)	47,9	42,8	6,5	2,8	2
Muddy Sand	5-10	223-319	275	(9,2)	50,8	34,4	7,3	7,5	9
Sandy Mud	10-20	207-352	262	(2,3)	14,5	45,2	24,1	16,2	28
" "	20-30	246-367	318	Traces	3,5	41,8	32,1	22,6	7
Mud	30-40	240-340	297	(0,5)	3,1	40,1	22,9	33,9	3
Underwater Slope of Murman									
Sand	<5	39-199	154	(4,2)	33,1	58,2	5,3	3,4	26
Muddy Sand	5-10	95-257	186	(5,5)	23,1	60,3	9,7	6,9	33
Sandy Mud	10-20	45-277	200	(4,1)	9,2	61,4	16,7	12,7	12
" "	20-30	69-289	213	(1,5)	5,9	37,6	30,5	26,9	7
Mud	30-40	150-275	227	Traces	0,5	31,1	35,4	32,9	3

2. Underwater Slope of Murman

The area of underwater slope of the Murman was considered by us to form a belt about 100 km wide along the coast of the Fenno-Scandinavian Shield, which comprises a part of USSR and extends from the Rybachiy Peninsula (poluostrov Rybachiy) on the west to Svyatoy Nos and the neck of the White Sea (gorlo Belogo Morya).

As was pointed out above, this area is characterized by a very complex relief, of the relict type, evidently, which is associated with the sinking of the structures of Rybachiy Island (poluostrov Rybachiy) and Kil'din Island (ostrov Kil'din).

At Rybachiy Island (poluostrov Rybachiy) and farther to the east, the underwater slope falls abruptly to 100 to 150 m, but then it forms a clearly pronounced terrace whose individual depressions exceed 200 m. In the direction of the neck of the White Sea (gorlo Belogo Morya) the terrace widens. The gradients are not large here. The hydrodynamic regime is characterized by great activity which is associated with tidal currents, swell coming from the northeast and north as well as from the coastal branch of the Nordkapp Current. Small local eddy currents - zones of lull - are formed at entrances to gulfs, as for instance in the so-called "triangle" between poluostrov Rybachiy and ostrov Kil'din whose deepest spot is called the Trawling Pit (Tralovaya Yama) (305 m).

The bottom of the steep coastal zone reached by strong tidal currents and subject to wave action is covered with shingle, gravel, shells and their fragments.[1] Along the coast, especially in the areas of islands ostrov Oleniy, ostrov Kharlov, ostrova Iokanskiye, near capes one can observe frequent outcrops of rocks occurring in their place of origin, individual cliffs and stones as well as scattered areas of boulders. The latter are found in straits, in the proliv (strait) Kil'dinskaya Salma, for instance, where the strong tidal currents carry away all of the smaller fragments. The coarse fragments are usually overgrown with /118 epifauna, places affected by swift currents are overgrown with lithothamnians. In areas that can be considered relatively calm because of protection by the coast (to the east of the Kil'din Island (ostrov Kil'din), at the entrance to Guba Teriberka, in the Gulf Svyatoy Nos (Svyatonosskiy zaliv), etc., for instance) a fine powdery sand is found, but to the north of Cape Svyatoy Nos (Mys Svyatoy Nos) shells with their fragments cover the bottom. At depths exceeding 100 m, coarse sediments are replaced by fine dust-like sand, but farther, at a depth of approximately 200 m muddy sand is found. The sand belt widens toward the east where it joins the sand lying in the neck of the White Sea (gorlo Belogo

[1] The bottom samples were collected during the following cruises of the survey ship Persei (Persey): the 6th in 1925, 12th and 13th in 1927, 17th in 1928; by T. I. Gorshkova; the 15th in 1926, 18th in 1929, 24th in 1931 by M. V. Klenova; the 19th in 1929 by K. R. Olevinskii; the 28th in 1930 by V. P. Zenkovich; the 44th in 1933 by E. F. Belevich, P. G. Popov, V. P. Zenkovich and P. S. Vinogradova; 49th in 1934 by P. N. Novikov; the 54th in 1935 by S. [illegible]. Malinin and Kuzovleva; during the following cruises of the survey ship Knipovich: the 24th in 1931 by K. A. Rachkovskaia; the 48th in 1934 by S. I. Malinin; the 52nd in 1935 by N. N. Khokhlin; of the survey ship Issledovatel': the 1st and 2nd cruises in 1937 and the 11th cruise in 1938 by P. S. Vinogradova.

Morya) and in the Kanin Shoals (Kaninskoye melkovod'ye). Sandy mud and mud are found only in the western part of the area at the entrance to the straits, Kol'skiy (Kola) zaliv, and Motovskiy (Motov) zaliv, as well as in the trench lying between the Rybachiy Peninsula (poluostrov Rybachiy) and R. Bank (Rybach'ya banka). Old clay is frequently seen on the slopes of the trench.

At shallow depths, the coarse sediments are not well sorted and contain an admixture of shells.

The sand of the Murman Shoals (Murmanskoye melkovod'ye) consists primarily of quartz containing an admixture of feldspar, which lends a rosy-gray hue to the sand. Near the coast and at projecting capes, the sand is enriched with gravel formed from the fragments of Murman and Kil'din rocks. In the western part of the area, in contrast to the Nordkapp Trench, the admixture of carbonate fragments is not great, but at places such as the Kil'din Bank (Kil'dinskaya banka), for instance, the sand is enriched with siliceous spicules which form a continuous cover, reminiscent of glass wool, after the sample has been rinsed on a sieve. Frequently the shells of sandy Hyperammina subnodosa are found.

In the eastern section of the Murman Shoals (Murmanskoye melkovod'ye) where, according to P. S. Vinogradova (1957), sloping underwater ridges with rocks occurring in their place of origin have been found by echo soundings to lie near the surface of bottom; the sand is represented by two types: the first type contains particles ranging from 1 to 0.1 mm,

present in greater than or in the same amount as the coarse silt (from 0.1 to 0.05 mm); fragments greater than 1mm are present in considerable quantity; the second type consists of a well sorted dust-like sand in which the quantity of coarse silt reaches 90% and the amount of gravel is negligible. A high degree of sorting is usually associated (N. V. Klenova, 1938) with a stable action of one factor, in this instance - with permanent tidal currents whose speed reaches 1 to 2 knots (0.5 to 1 m/sec). The material whose sorting is not so pronounced and which contains an admixture of coarse fragments is found at the surface of the ridges, delineating for instance the Kil'din Bank (Kil'dinskaya banka), though its relief is not well pronounced (fig. 36).

At a depth of approximately 200 m the bottom of the Murman Shoals (Murmanskoye melkovod'ye) is covered with a muddy sand having a greenish-gray color, which is usually well sorted. Sometimes the muddy sand contains lumps of clay washed out of the underlying layers; in such a case its mechanical composition is characterized by a graph forming two peaks (for instance St. 941, 200 m and St. 942, 200 m).

The accumulation of eroded material from old clay deposits leads sometimes to the appearance of a more fine-grained material at small depths, as for instance in the southern part of the cross section along the 32nd meridian near the Rybachiy Peninsula (poluostrov Rybachiy) (fig. 33; St. 3329, 69 m and St. 3330, 180 m), while at greater depths, farther to the north, a coarser material is deposited. An enrichment with small fragments is also observed off the entrance to the gulfs of Kol'skiy (zaliv) and

Notovskiy (zaliv) in the Trawling Pit (Tralovaya Yama) forming a trap of sorts to catch the particles. Here, as in the case of cross section along the 32nd meridian, the graph having 2 apices to characterize the mechanical composition is in the upper part of the slope replaced by one apex with a maximum in the fine silt at a great depth (fig. 37).

The layer of contemporary deposits on the Murman submarine slope is not thick. Under the layer whose thickness ranges from 7 to 13 cm one can find deposits of a different composition, most frequently a rosy-gray or bluish-gray clay.

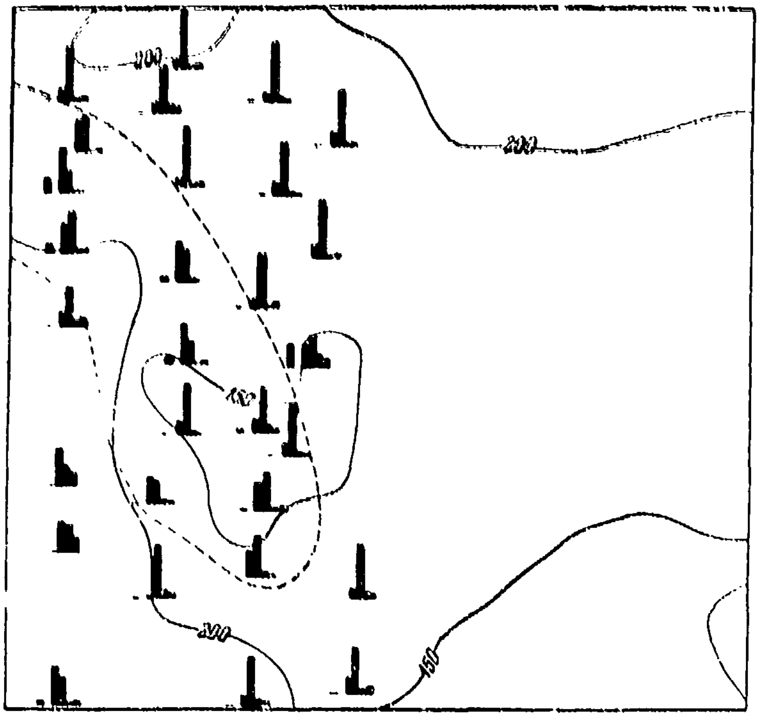

Fig. 36. Changes in the type of mechanical composition of sediments on the Kil'din Bank (Kil'dinskaya banka). (For designations see fig. 33).

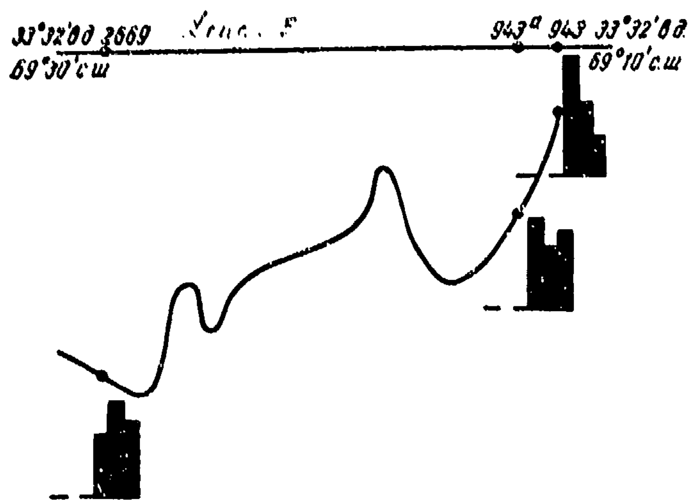

Fig. 37. Changes with depth in the mechanical composition of sediments in the Trawling Pit (Tralovaya Yama). (For designations see fig. 33).

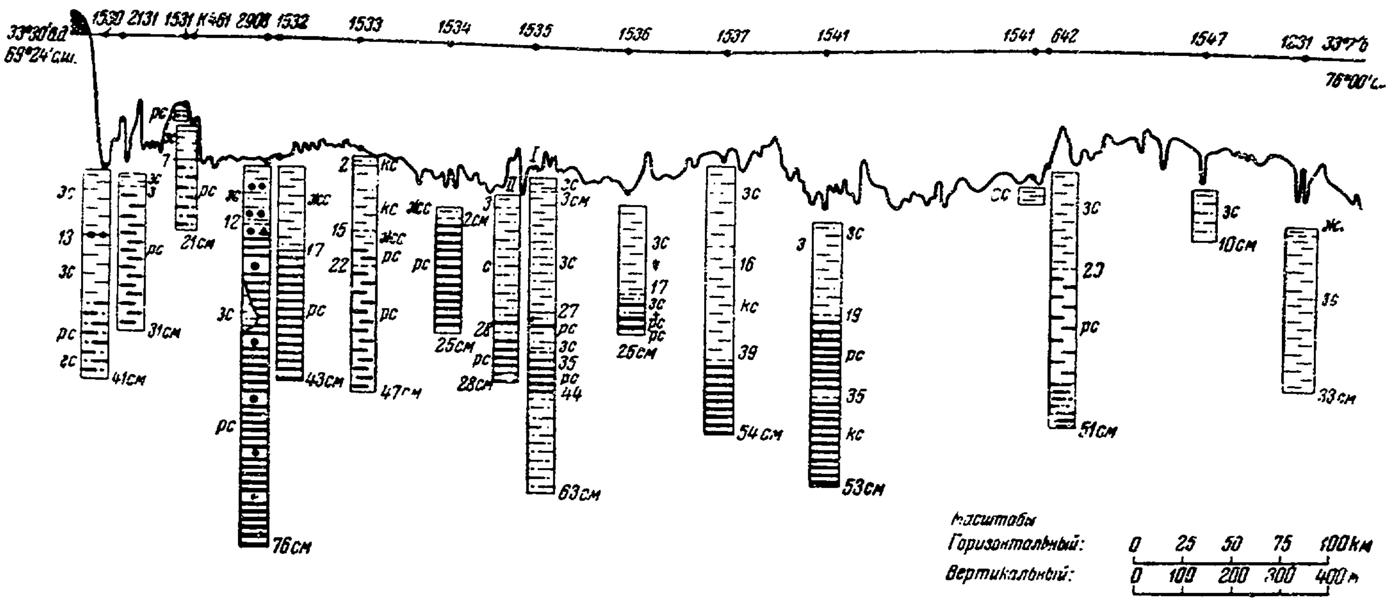

Fig. 38. Profile along the Kola Meridian ($33^{o}30'$). (For designations see fig. 46).

Key. The three horizontal lines in the lower right-hand corner of the graph are:

Scales

Horizontal 0 - 100 km

Vertical 0 - 400 km.

A protective layer of coarse material is accumulating on the surface of an active washout of underlying deposits (fig. 34, 3; St. 673, 219 m, at the entrance to the Motovskiy Gulf (Motovskiy zaliv)). In the column the contemporary sandy mud layer is 23 cm thick; deeper, to 53 cm (the end of core) a dense, heavy clay with alternating rosy and bluish-gray layers is found; at discontinuities a slight admixture of sand occurs.

In the central part of the Motovskiy Gulf (Motovskiy zaliv) (St. 666, 228 m) under a layer 13 cm thick consisting of greenish-gray sandy mud with worm holes, gravel, and sandy and calcareous rhizopods lies a stratified layer consisting of light-gray, almost white, clayey mud and greenish-gray mud, which is possibly an alteration of rocks occurring in their place of origin.

The cores obtained at the cross section extending along the Kola meridian (33°30'; fig. 38) from under a layer of greenish-gray muddy sand or sandy mud with fragments of mollusks, shells of Leda sp., Astarte sp., which were sometimes wrapped in ocherous rings with calcareous foraminifera, contained a rosy-gray clay, more or less sandy, enriched with gravel and small shingle (rosy-colored granite, gray sandstone). Farther to the east, under the contemporary sediments, lies a pinkish-gray clay (St. 678, 196 cm) or a stratified greenish-gray and rosy-gray mud slightly effervescent with HCl (St. 1072, 161 m). On the slope of the Southern Murman Bank (Yuzhnaya Murmanskaya banka) a transitional layer only 2 cm thick and consisting of a mixture of greenish-gray muddy sand and rosy-gray clayey mud lies under a layer of muddy sand 7 cm thick. On cores

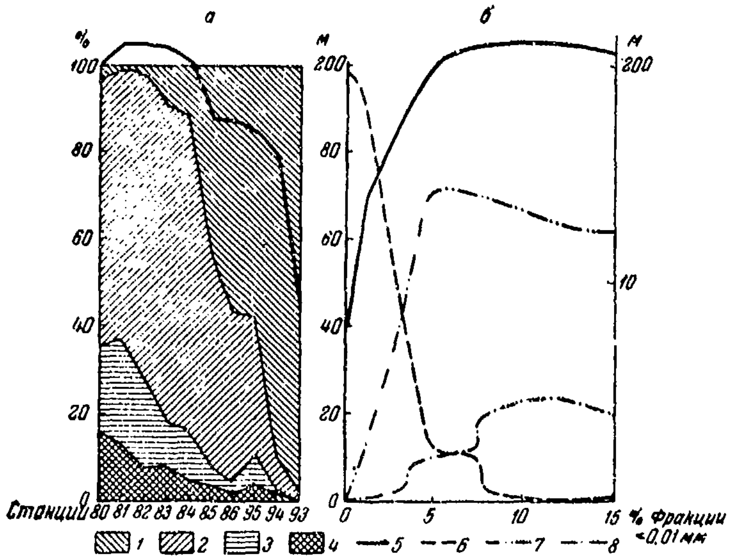

Fig. 39. Mechanical composition of sediments in connection with depth. A cross section along the meridian 36°.

a -- distribution of fragments by stations: fragments: 1 -- 1 to 0.1 mm; 2 -- 0.1 to 0.05 mm; 3 -- 0.05 to 0.01 mm; 4 -- smaller than 0.01 mm; 5 -- depth (in meters). б -- distribution of coarse fragments in connection with the content of particles smaller than 0.01 mm; fragments: 6 -- 1 to 0.1 mm; 7 -- 0.1 to 0.05 mm; 8 -- 0.05 to 0.01 mm.

At the bottom of the figure, left to right:

Stations - - - - - - - - - - - - - - - 15% fragments <0.01 mm.

9 cm long (St. 258, 200 m) lies a uniform clay with subconchoidal fractures of rosy- or violet-gray color.

Lying near the surface of the bottom, especially on slopes, the old clay shows an admixture of fine-grained material at washouts so that at times the mechanical composition of the upper sediment layer is presented by a graph having two apices. This is reflected in graphs depicting the /122
average mechanical composition (table 5 and fig. 35) where a bend in the curve representing the coarse silt reflected the inflow of a new material interrupting the successive pattern of mechanical differentiation. On the smooth surface of the Murman Shoals (Murmanskoye melkovod'ye), for instance in the cross section along the meridian of long. 36° E, the quantity of individual fragments changes uniformly with increase in depth from 80 to 211 m, but the graph representing their mutual relation attests to an abrupt shift of composition at a depth of approximately 180 m (fig. 39).

3. Pre-Kanin Area
(Prikaninskiy rayon)

The pre-Kanin area consists of the northern section of the White Sea Funnel (Voronka Belogo Morya) and a belt 50 km wide around the Kanin Peninsula (poluostrov Kanin) to the entrance to Cheshskaya Guba (Ch. Bay). Between the Terskiy Coast (Terskiy bereg) of the Kola Peninsula (Kol'skiy poluostrov) and the east coast of the Kanin Peninsula (poluostrov Kanin) the bottom relief is very smooth and only in the southern part of the submarine plain, nearer to Mezenskaya Guba (Mezen' Gulf or

Mezenskiy zaliv), appear sloping elevations. A rougher relief is observed near the Cape Kanin Nos (Mys Kaninskiy Nos), it extends in northwestward direction. A rather steep slope is found along the north coast of the Kanin Peninsula (poluostrov Kanin) to a depth of 20 to 25 m. Toward the north its slope gradually becomes gentle to 50 to 60 m, but toward the east the angle of declination becomes steeper due to the extension of the original rocks of the Kryazh Kanin Kamen' (Kaninskiy Kamen', i.e. the Kanin Stone). Farther to the east a sloping bottom extends toward the Kolguyev Island (ostrov Kolguyev) and Cheshskaya Guba (V. P. Kal'ianov and V. P. Androsova, 1933; the studies by P. S. Vinogradova, M. V. Klenova and V. P. Zenkovich, and E. K. Kopylova).

The sediments of the pre-Kanin area are represented predominantly by sand with a considerable amount of coarse fragments as well as with shells and barnacles and their fragments.[1]

The principal active processes of the hydrodynamic regime are the powerful tidal and, permanent currents. They actively erode the bottom, especially along the submerged coastal line which consists of indentations of the 50 m isobath where often the outcrops of original clay are observed. Investigations concerning the productivity of bottom

[1]The bottom samples were obtained by T. I. Gorshkova during the following cruises of survey ship Persei (Persey): the 4th in 1924 and 13th in 1927; by M. V. Klenova during the following cruises of the same vessel: the 8th in 1925, 10th in 1926 and 15th in 1928; by P. N. Novikov during the 49th cruise of the same vessel in 1934, and by N. N. Khokhlin during the 52nd cruise of survey ship Knipovich in 1935.

fauna (L. A. Zenkevich, 1930) demonstrate a great variety and profusion of benthos consisting mainly of mollusks, crustaceans and worms, but containing also spots of mud around the Cape Kanin Nos (Mys Kanin Nos). A mechanical analysis showed that the bottom here is covered with muddy sand containing patches of sandy mud. Isolated outcrops of muddy sand, which sometimes border on sandy mud, have been found in coastal areas along the west coast of Kanin, mainly off the estuaries of rivers. This is associated with an intensive erosion of the Quaternary deposits which form the coast (V. P. Kal'ianov and V. P. Androsova, 1933).

In the western section of pre-Kanin area, which adjoins the Funnel of the White Sea (Voronka Belogo Morya), the bottom is covered by a well sorted pure medium sized sand (St. 710, 65 m; St. 122, 70 m, etc.) where particles prevail from 0.5 to 0.25 mm (fig. 40). The color of the sand is either yellow or yellowish-gray, sometimes white, but nearer to the Kola Peninsula (Kol'skiy poluostrov) it is rosy-gray consisting of rounded and subangular grains of quartz with a considerable admixture of feldspar and dark minerals - hornblende, magnetite, ilmenite, dark mica, rosy garnet. The carbonate remains, such as the fragments of barnacles, Cardium sp., Buccinum undatum - are found in small quantities.

Toward the north on the extension of Cape Kanin Nos (Mys Kanin Nos - St. 123, 65 m; St. 706, 64 m) the marked sorting of sand becomes less pronounced (fig. 41, a) and it begins to contain a considerable admixture of whole shells and particles of Saxicava arctica, Pecten islandicus, Astarte sp., Leda sp., fragments of Pecten. Further, the sand is

enriched with shingle and gravel which are frequently overgrown with pearlweeds. Among shingles, mainly fresh and well-rounded ones, one can find gray, rosy and yellowish sandstone, plagioclase and orthoclase granite, weathered fragments of igneous rocks of diabase type.

Toward the east and south the average type of sand is replaced by a clearly washed and well assorted fine sand (fig. 41, б) of yellowish-gray (St. 721, 75 m) or white color with a rosy hue (St. 737, 69 m; St. 738, 64 m).

In eastward direction the sand becomes more fine-grained, turning into a dust-like sand (fig. 41, b,г) and later into muddy sand. Along the coast line lies a pure dust-like sand (St. 730, 20 m) consisting of subangular quartz grains which include magnetic particles. The sand contains an admixture of feldspar, carbonate remains, calcareous /124
rhizopods and small shells Astarte sp., as well as a small amount of mica. Analogous is the sand lying on the smooth underwater slope to the north of Kanin Peninsula (poluostrov Kanin) which is subject to the action of waves and tidal currents (St. 494, 34 m; St. 497, 55 m).

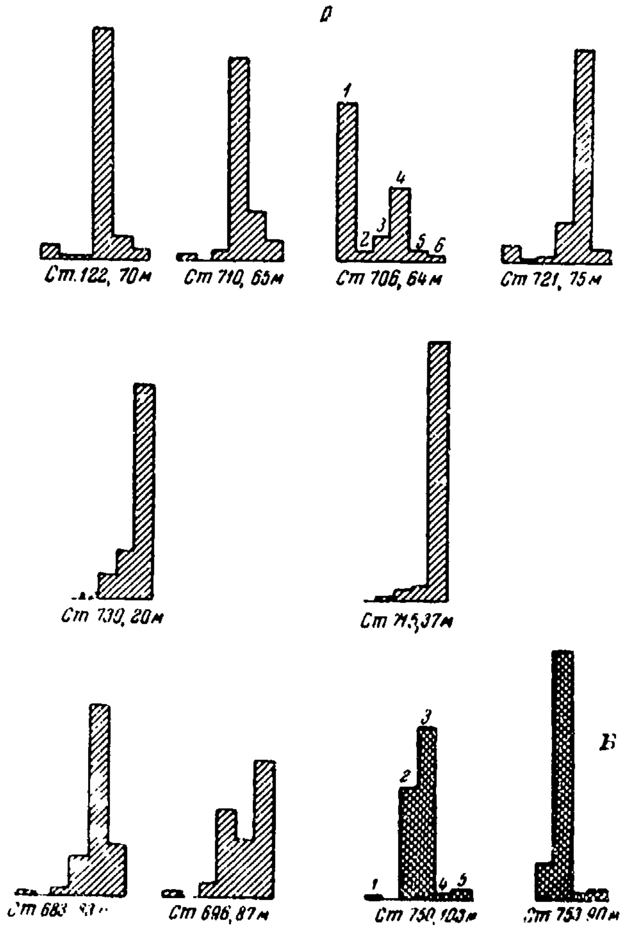

Fig. 40. Mechanical composition of sand in the pre-Kanin area.

A -- histograms of screen analyses. Fragments: 1--greater than 2 mm; 2--2 to 1 mm; 3--1 to 0.5 mm; 4--0.5 to 0.25 mm; 5--0.25 to 0.1 mm; 6--smaller than 0.1 mm; Б -- histograms of water analyses: Fragments: 1--greater than 1 mm (are subtracted from samples and are not included in the sum of 100%); 2--1 to 0.1 mm; 3--0.1 to 0.05 mm; 4--0.05 to 0.01 mm; 5--smaller than 0.01 mm.

Horizontal lines beneath the graph, from left to right: Station 122, at 70 meters, etc.

The assortment of sand is considerably less pronounced on the extension of the Cape Kanin Nos (Mys Kanin Nos; St. 489, 78 m), to the north of it (St. 493, 65 m) and 15 miles to the north of the Cape Laydënnyy (Mys Laydënnyy; St. 500, 65 m). Everywhere in the areas, the sand has a yellowish-gray or even pink-gray color and contains few small rounded shingles of sandstone and basalt.

The muddy sand near the Cape Kanin Nos (Mys Kanin Nos) and to the south of it is characterized by a pronounced predominance of coarse silt having a slightly yellowish-gray color changing to a greenish-gray color; downward in the column it becomes more fine-grained. Only to the south of the Cape Kanin Nos (Mys Kanin Nos) and on the northern slope of the peninsula does the muddy sand contain a noticeable admixture of sand particles (St. 488, 59 m; St. 704, 56 m; St. 492, 61 m); it consists basically of quartz containing single, coarse rounded grains, sometimes with an admixture of quartz gravel; however, in contrast to sand, it contains a considerable portion of mica.

To the north of Cape Kanin Nos (Mys Kanin Nos), on a sloping depression, a spot of sandy mud has been noticed (St. 124, 62 m; St. 702, 58 m; St. 2755, 64 m; St. 2756, 64 m; and St. 1855, 64 m). Its color is yellowish-gray, its structure is compact containing a large quantity of fragments of mollusks *Cardium* sp., *Pecten islandicus*, *Nucula tenuis*, tubes of worms, sandy rhizopods of *Hyperammina* sp.

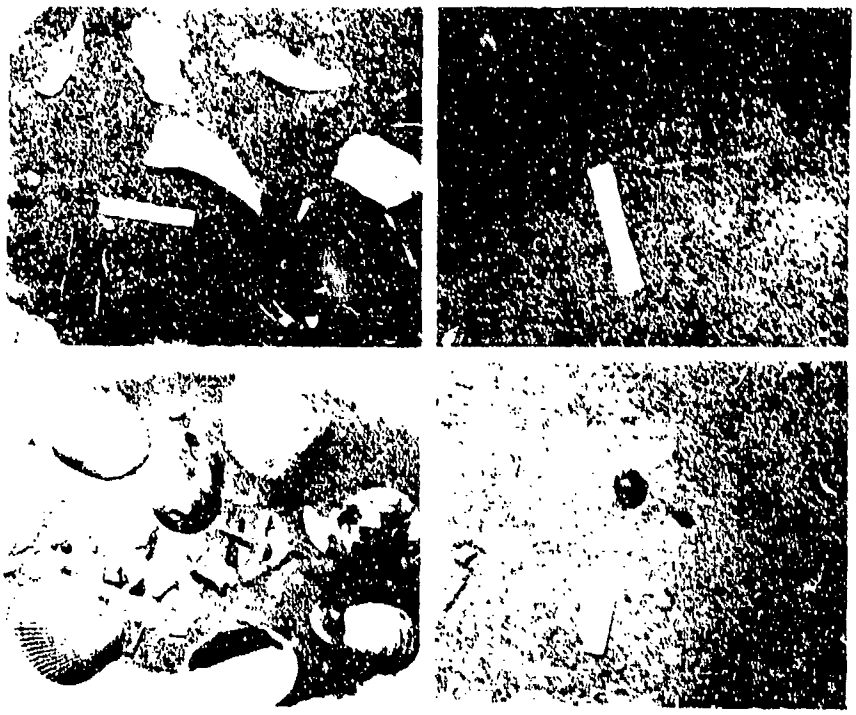

Fig. 41. The sand of Kanin-Kolguyev Shoals.

a -- St. 683, 83 m, fine sand with fragments of shells and barnacles; б -- St. 696, 87 m, powdered sand of yellowish-gray color (to the south of underwater extension of Kaninskiy Khrebet(Kanin Range)); b -- St. 750, 103 m, dust-like sand, poorly sorted, yellowish-gray color, overgrown with shells of barnacles Cardium and with partly dissolved Astarte; г -- St. 753, 90 m, dust-like sand, greenish-gray, well sorted, with organic remnants.

The sandy mud contains a considerable admixture of sand as well as gravel and shingle consisting of a fine-grained rosy colored granite, gray schist and gray limestone.

The origin of sandy mud, as well as that of muddy sand, is associated with the erosion of deposits of Quaternary transgressions, which are exposed at places on the Kanin coast and lie at shallow depths on the underwater slope beneath the layer of contemporary sediments. According to the information obtained by commercial trawling, the boards of trawls often cut here the upper layer of sand and bring up a viscous clay. Although the depth does not increase more than 5 m, a relatively calm zone with a less intensive hydrodynamic activity is found here. The presence of a hydrodynamically calm zone to the north of the Kanin Peninsula (poluostrov Kanin) is confirmed by direct measurements of current speeds as well as by the distribution of ice. It is here that an accumulation of concentrated ice floes is preserved longer than elsewhere (V. A. Vasnetsov, 1938). Erosion and inflow of new material are also reflected in the results of the mean mechanical composition (table 6 and fig. 35, b).

Table 6

THE MEAN MECHANICAL COMPOSITION OF SEDIMENTS

Bottom Type	Fractions <0.01 mm in %	Depth in m		Fraction in mm					Number of Analyses
		from-to	mean	> 1	1-0.1	0.1--0.05	0.05--0.01	<0.01	
Pre-Kanin Area									
Sand	<5	20-78	49	(0,9)	25,6	65,7	5,9	2,8	19
Muddy Sand	5-10	45-61	55	(0,4)	14,5	68,5	10,1	6,9	7
Sandy Mud	10-20	58-64	62	(0,4)	16,7	49,7	21,0	12,6	5
Kanin-Kolguyev Area									
Sand	<5	70-87*	90	(2,8)	39,9	52,6	4,6	2,9	21
Muddy Sand	5-10	63-149	103	(3,7)	35,1	49,1	9,2	6,6	18
Sandy Mud	10-20	132-206	161	(1,0)	20,1	46,9	19,5	13,5	3

*Dust-like sand. The depths of the average sand are 55 to 62 m, for the fine sand 61 to 90 m.

4. The Kanin-Kolguyev Area

The Kanin-Kolguyev area presents large shoaling waters at a depth of about 100 m between the pre-Kanin area, the Kolguyev Island (ostrov Kolguyev) on the east and the Goose Bank (Gusinaya banka) on the north. The western boundary with the area of the Murman Bank (Murmanskiye banki) runs between isobaths 100 and 150 m. The surface of the Kanin-Kolguyev shoals is exclusively smooth which has also been confirmed by detailed measurements carried out during the recent years. However, they demonstrated that (fig. 14, bathymetric chart) that the slopes of the Kanin Bank (Kaninskaya banka) are indented by valleys which lead toward the southern branch of the Central Depression of the Barents Sea on the southwest and toward the depression between banks Gusinaya and Kaninskaya on the north.

The sediments in the Kanin-Kolguyev area are represented mostly by sand.[1] Toward the Goose Trench (Gusinyy Zhelob) the sand covering this slope is replaced by muddy sand and sandy mud. The muddy sand is deposited in underwater valleys between the northern slope of the Murman Shoals (Murmanskoye melkovod'ye) and the southern slope of the Kanin Bank

[1] The following data have been used: by T. I. Gorshkova obtained during the 4th and 6th cruises of Persei(Persey) in 1924, during the 13th cruise in 1927; by M. V. Klenova obtained during the 10th and 18th cruises of Persei in 1926 and 1929, respectively; by P. N. Novikov obtained during the 49th cruise of Persei (Persey) in 1934; by S. I. Malinin obtained during the 43rd cruise of survey ship Knipovich in 1934 and by N. N. Khokhlin obtained during the 52nd cruise of Knipovich in 1935.

(Kaninskaya banka), as well as between the northern and southern branches of the latter. A spot of muddy sand has been found at depths of 50 to 75 m between the Kanin Peninsula (poluostrov Kanin) and the Kolguyev Island (ostrov Kolguyev). The replacement of sand with muddy sand and sandy mud also occurs westward and northwestward toward the southern part of the Central Depression (Tsentral'naya vpadina).

The sand in the area of Kanin-Kolguyev Shoals (Kaninsko-Kolguyevskoye melkovod'ye), as in the Kanin area, consists predominantly of quartz. Its color in the majority of cases is yellowish-gray, the sand is well washed and assorted and it contains, in addition to quartz, feldspar, a small admixture of magnetite and ilmenite, as well as the rosy-colored garnet, which can be readily noticed even by examination with binoculars. At places, due to the admixture of feldspar and the rosy-colored micaceous sandstone (St. 125 to 127 between the Kanin Peninsula (poluostrov Kanin) and the Kolguyev Island (ostrov Kolguyev) at depths of 79 to 36 m)), the sand acquires a rosy-gray hue. Nearer to the coast it has a pinkish-gray color (St. 158, 58 m), but in the western portion of the area a greenish-gray color (St. 236, 95 m; St. 682, 90 m; St. 683, 83 m, etc.).

In the eastern portion of the area and at smaller depths in the central section of the Kanin Bank (Kaninskaya banka) and nearer to the Kolguyev Island (ostrov Kolguyev) the sand becomes coarser, so that the prevailing size of fragments ranges from 1 to 0.1 mm, whereas in the western part and at great depths the fine, dust-like sand prevails. Admixture of

shingle is limited. One can find single shingles and small boulders overgrown with sponges, hydroids, barnacles and sometimes with lithothamnions. Nearer to the coast the quantity of shingle increases and also there appears a considerable quantity of gravel consisting of smooth quartz grains, rosy-colored feldspar, fragments of rocks, such as basalt, micaceous sandstone and carbonate fragments of organisms. Especially large numbers of fragments of shells and barnacles are found off the entrance to Cheshskaya Guba (St. 537, 55 m) and on an isolated shoal to the north of ostrov Kolguyev (K. Island - St. 779, 70 m) where also gravel consisting of fragments of gray schist and limestone, sometimes with ocherous rims, has been found.

The fine sand of the southwestern portion is characterized by pronounced sorting and a small admixture of shells and their fragments - namely: Mya truncata, Astarte sp., Balanus, Tellina baltica, Cardium (fig. 41, St. 683, 83 m etc.). The sorting of the average sand (St. 686, 62 m) to the north of the underwater extension of the Kanin Ridge (Kaninskiy Khrebet) and that of dust-like sand to the south of it (St. 696, 87 m) is rather less pronounced (fig. 40, A. Б).

In order to explain the distribution pattern of sand sediments and the smoothened original rocks underlying the sand, it is necessary to carry out thorough investigations.

On the slopes of Kanin Shoals (Kaninskaya banka) the dust-like sand (silt) is represented by two types. On the western slope it contains a considerable admisture of sand (1 to 0.1 mm) whose mechanical composition,

when expressed graphically, is represented by two rather marked apices (St. 750, 103 m; St. 752, 96 m; St. 753, 90 m). In the valley to the south of Kanin Shoals (Kaninskaya banka), evidently in an area of accumulation (St. 246, 107 m; St. 1108, 105 m) the resultant graph has only one apex. Among the organic remains in the sand covering the Kanin Shoals (Kaninskaya banka) one can find chitinous tubes, fragments of shells, including partly dissolved shells of Astarte borealis, fragments of the large barnacle and large Cardium ciliatum with traces of fouling. The dissolved particles contain also other carbonaceous remnants, including the shells of Saxicava (fig. 41). Such a character of organic remains among which an unusually dense admixture of fossil shells is found, as well as the type of mechanical composition, point out that the source of the material is not of our times. The coarse-grained portion of Quaternary rocks, which has been subject to intense erosion on the slopes of shoals and on the coast, has accumulated here. The active hydrodynamical regime - i.e. the swell[1] and tidal currents /127
at the presence of relatively steep slopes (fig. 42) determine the erosion and partial redeposition of the material that had been deposited earlier.

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[1]On the Kanin-Kolguyev Shoals, the swell and tidal currents moving from the north and west are subject to the greatest deformation, but the water here is less transparent than in the other sections of the open sea.

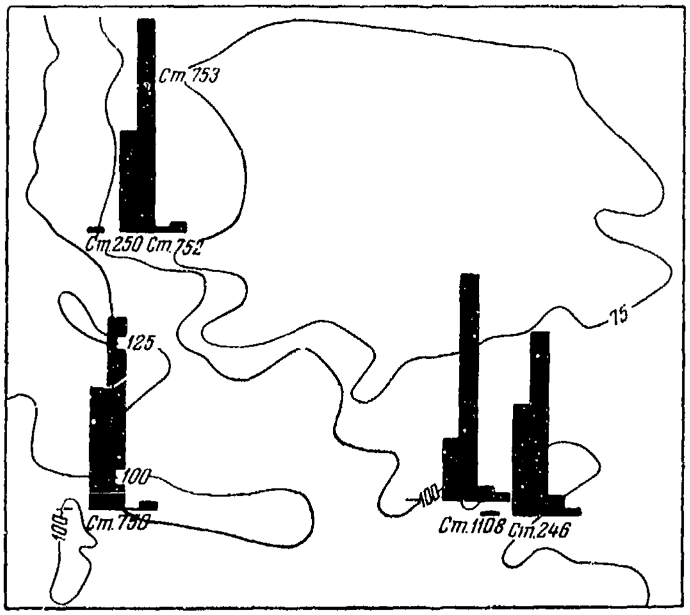

Fig. 42. Mechanical composition of sediments on the slopes of the Kanin Bank (Kaninskaya banka) (For designations see fig. 33).

Cm -- St(ation).

The mechanical and structural composition of the sand covering the northern portion of Kanin Shoals or Bank (Kaninskaya banka) and the slope toward Goose Trench (Gusinyy Zhelob) that separates it from the Goose Shoals (Gusinaya banka) differs little from that covering the western slope which has already been discussed. Also here a considerable admixture of fragments ranging from 1 to 0.1 mm is found, as well as carbonaceous remnants and whole shells, such as Pecten islandicus, which is sometimes overgrown with barnacles (St. 682, 119 m), some gravel, and shingle consisting of gray quartzite, red sandstone, diabase, granite. The large grains of quartz are rounded, but the two apices in graphical presentation are not pronounced because at the present time the area is evidently characterized by deposition.

The color of the muddy sand lying between Kanin Peninsula (poluostrov Kanin) and the Kolguyev Island (ostrov Kolguyev) and to the north of Kanin at a depth of approximately 60 to 70 m (St. 161, 75 m; St. 362, 63 m; St. 501, 64 m) is yellowish-gray; when dry, the muddy sand is slightly cemented in lumps containing a considerable amount of sand. In addition to the predominant quartz, feldspar and dark black minerals, including magnetite, the muddy sand contains a noticeable quantity of mica. The less intensive hydrodynamical activity of the medium makes it possible for the flakes of mica to remain in the sediments. Among the few grains of gravel and shingle, which have been intensely weathered, rounded and overgrown with bryozoans and serpulids, there occur quartzite, clay layers, limestone and fragments of lithothamnions.

In the valley between Kanin Shoals (Kaninskaya banka) and the Murman Shallows (Murmanskoye melkovod'e) at a depth of 100 to 125 m (Stations 237 and K 1857) the quantity of sand particles is smaller, but on the northern and eastern slopes of the Kanin Bank (Kaninskaya banka) the quantity of the particles increases at places (at St. K 1896, 85 m, to the north of Kolguyev, for instance). Here a core of muddy sand (St. /128
2748, 89 m) contains a considerable quantity of gravel but at a depth of 12 cm a layer of coarser sand with calcareous rhizopods occurs.

In the valley between the northern and southern spurs of Kanin Bank (Kaninskaya banka) the muddy sand is gradually replaced by sandy mud reminiscent of muddy sand (St. 751, 206 m; St. K 1330, 145 m, etc) as the depth increases. But at the eastern end of the Goose Trench (Gusinskiy Zhelob) the replacement takes place as the distance from the slope of the Central Depression increases.

As regards the composition of the sand, only the presence of an ocherous admixture and a rather better cementation in dry condition is to be noted. Toward the bottom of the cores, the sandy mud turns gradually into a uniform greenish-gray mud (St. 751; the length of the core being 53 cm) or into a finer-grained sandy mud (St. 781; the length of the core being 27 cm).

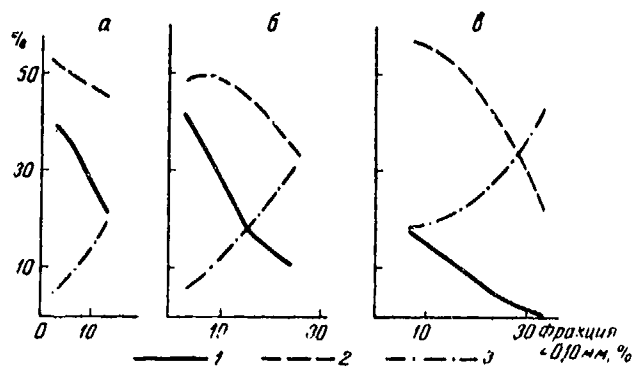

Fig. 43. The mean mechanical composition of sediments in the southern portion of the Barents Sea in areas characterized by accumulations.

a -- 4th area, Kanin-Kolguyev Shoals (Kaninsko-Kolguyevskoye melkovod'ye); б -- 7th area, Pechora Shoals (Pechorskoye melkovod'ye); в -- 9th area, the Central Plateau; fragments: 1 -- 1.0 to 0.1 mm; 2 -- 0.1 to 0.05 mm; 3 -- 0.05 to 0.01 mm.

On the whole the Kanin-Kolguyev Shoals (Kaninsko-Kolguyevskoye melkovod'ye) is an area characterized by coarse-grained sediments resulting from the washouts of Quaternary sediments. The White Sea water, carrying evidently the suspended particles of the River Severnaya Dvina (M. V. Klenova, 1952), deposits here a small quantity of sesquioxides, iron for instance, which lends a yellow and pink color to the sand.[1] The sand and silt sediments that have been redeposited many times form a thick protective layer which cannot be pierced by light instruments. Therefore data on thickness are not at our disposal. It is suggested that the thickness is considerable because the underlying layer, except for the slopes of elevations, is not detected by trawling.

Because the old rocks are not exposed anywhere, a clear connection between changes in mechanical composition and the depth is observed. On the western slope of Kaninskaya banka the eroding sediments occupy a small area. The average composition does not disclose traces of erosion and curves indicate a gradual and uniform decrease in the quantity of fragments ranging from 1 to 0.1 mm and from 0.1 to 0.05 mm with increase in the content of particles < 0.01 mm and the fine silt ranging from 0.05 to 0.01 mm (table 6 and fig. 43).

[1] The ferric oxide in the sediments is characterized by its mobility. Thus, in a sample of pink sand (St. 158, 58 m) which was kept for 14 years in a jar filled with paraffin, a considerable displacement of sesquioxides had taken place. Only the upper layer (about 2 cm) had preserved the pink color. Under it, pink interlayers 0.5 mm thick were observed at a distance of 2 to 3 mm from one another. Farther, the pink color was preserved only in spots, but at 7 to 8 cm a pronounced interlayer had been formed. Beneath it a pinkish-gray sand with diffuse yellow and gray spots could be observed. At the bottom of the jar, periodic reactions occurred.

5. The Murman Bank
(Murmanskaya banka)

The projection of the 200 m isobath extended to the northwest and situated to the west of the Kanin-Kolguyev Shoals is called the Murman Bank (Murmanskaya banka). At depths ranging from 100 to 200 m it forms two sloping elevations situated en echelon with respect to each other. These are the Southern Murman Shoal (Yuzhnaya Murmanskaya banka), bounded by 150 m and 175 m isobaths, and the Northern Murman Shoal (Severnaya Murmanskaya banka) whose depths are approximately 165 m and which rise over the underwater shelf whose depth is approximately 200 m. The boundaries of the area include also the spur of an elevation lying at a depth not exceeding 250 m and extending in the same northwestern direction. In the north it delimits the eastern part of the Norwegian Trench separating the Murman Shoal (Murmanskaya banka) from the coastal shoaling waters of Murman (Murmanskoye melkovod'ye).

Between elevations of the Murman Bank (Murmanskaya banka) there are sloping depressions the amplitude of their relief variations ranging from 20 to 25 m. The detailed depth soundings show that the slopes of the shoal, especially at a depth of 200 m and to a certain degree at 250 m, are characterized by indentations. Numerous valleys descend from the slope toward the northeast into the Central Depression of the Barents Sea and toward the southwest in the direction of the Norwegian Trench. The slopes and the surface of the Murman Bank (Murmanskaya banka) abound in stones, and in a number of places old rocks, evidently, the Quaternary clay, are found beneath a negligibly thin layer of contemporary sediments.

The highest areas of the Murman Bank (Murmanskaya banka) are covered by sand and muddy sand which is replaced by sandy mud in depressions.[1] Coarse fragments are found in great quantities. On every slope, especially on the northeastern one, they have been found by trawls, which attests to the presence of outcrops of original rocks. The coarse fragments have also been noticed between troughs on the outcrops of the southwestern slope. The outcrops of old clay are limited to the 200 m isobath and they have been disclosed by all types of instruments (used in the collection of samples) and by commercial trawls.

The composition of the sand covering the eastern part of the Murman Bank (Murmanskaya banka) is analogous to that of the sediments covering the southwestern part of Kanin-Kolguyev Shoaling water (Kaninsko-Kolguyevskoye melkovod'ye), i.e. it is primarily a quartz sand with coarse rounded grains containing feldspar, mica and fragments of dark ferrous rocks. The difference lies in a smaller quantity of non-ferrous metals which are not detected by binoculars in the samples taken from the Murman Bank (Murmanskaya banka). The admixture of carbonate fragments and gravel is negligible. In addition to mollusks, the tiny Astarte sp. for instance, one can find calcareous and siliceous rhizopods, plates and spines of

[1]The writer has used the data obtained during the following cruises by the survey ship Persei (Persey): the 6th in 1924, 12th and 13th cruises in 1927, 17th in 1928, 50th in 1934 by T. I. Gorshkova; the 18th cruise in 1929 by M. V. Klenova; the 28th cruise in 1930, by V. P. Zenkovich; the 54th cruise in 1935 by S. I. Malinin and Kuzovleva; and during the following cruises by the survey ship Knipovich: the 48th in 1934 by S. I. Malinin; the 52nd in 1935 by N. N. Khokhlin.

sea urchins, chitinous tubes of worms. At smaller depths fine sand is deposited (St. 748, 108 m; fig. 44, 2) but with increase in depth, the proportion of sand particles decreases and the sediment assumes the character of a silty sand (St. 247, 150 m; St. 255, 165 m; fig. 44, 1).

The muddy sand, which is widely distributed in the eastern part of the Murman Bank (Murmanskaya banka), is represented by two types (fig. 44, 3 and 4). The muddy sand on the slope lying toward the Murman Trench (the eastward extension of the Norwegian Trench between the Murman Bank or Shoal (Murmanskaya banka) and the Murman coastal shoals) consists predominantly (to 82.5%) of coarse silt particles (St. 628, 146 m; St. 1118, 210 m). There it contains quartz with a small admixture of feldspar and organic remains in the form of chitin, sponge spicules, worm tubes, a few calcareous rhizopods, and other carbonate fragments.

The other type of muddy sand, whose sorting is considerably less pronounced, contains a large amount (to 50.7%) of sand particles. It is found near the slope of Kanin-Kolguyev Shoaling Water (Kaninsko-Kolguyevskoye melkovod'ye); (St. 749, 140 m; St. 1078, 190 m, etc.) on the northern slope of the Murman Bank (Murmanskaya banka) (St. 261, 210 m; St. 1064, 217 m). /130

A typical type of sediment on the Murman Bank (Murmanskaya banka) is the sandy mud which is related to the muddy sand (about 10% of particles are smaller than 0.01 mm). The mechanical composition of the sand covering the slopes of underwater elevations, for example the northwestern end of the Southern Murman Shoal (Yuzhnaya Murmanskaya banka) (St. 259, 140 m),

the northern slope (St. 1066, 165 m; St. 631, 249 m) and the south-western slope (St. 1068, 195 m), are described by graphs having two apices, but the mechanical composition of the sand covering depressions, i.e. the areas characterized by depositional processes (St. 260, 183 m; St. 262, 190 m, etc.), are described by graphs having one apex. To the north, on the slope extending toward the Central Depression, which is traversed by one of the principal branches of the Nordkapp Current, the sandy mud, as well as the muddy sand (fig. 44, 5 and 6) are characterized by an increase in the content of fragments from 0 to 0.1 mm and by the presence of small shingle, gravel and organic remains in the form of spines, chitinous worm tubes, calcareous rhizopods and carbonate fragments (St. 631 and 1078; fig. 45).

The sandy mud lying on the slope which stretches toward the Norwegian Trench (on the Kola Meridian 33°30') is characterized by a great variety of elements, but on the whole it is represented by various types having one apex in the graphs showing their mechanical composition (St. 1535, 272 m; St. 2906, 233 m, etc.).

Cores of two layers were taken at almost all the stations on Murman Shoal (Murmanskaya banka). The thickness of the upper greenish-gray layer of sediment varies from 2 to 33 cm. Under it lies a layer of different composition - usually gray, sometimes a sandy or viscous clay with a noticeable rosy-colored hue. A minimum thickness of the upper layer is observed on slopes and the graphs of its mechanical composition /131
are always characterized by the appearance of two apices.

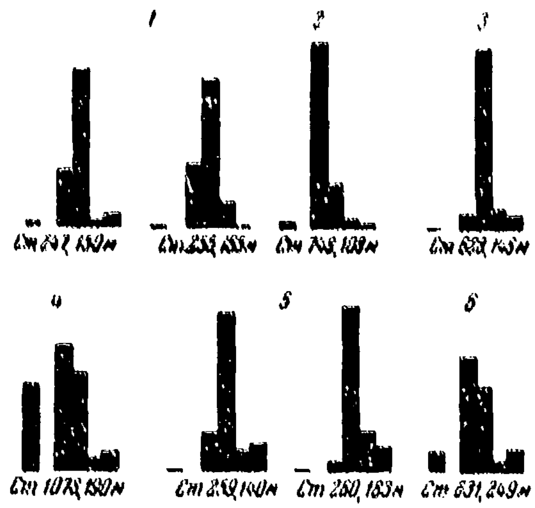

Fig. 44. Types of mechanical composition of sediments on the Murman Bank (Murmanskaya banka):

1--silty sand (St. 247, 150 m; St. 255, 165 m); 2--fine sand (St. 748, 108 m); 3--muddy sand, well sorted (St. 628, 146 m); 4--muddy sand on the underwater shelf whose sorting is not pronounced (St. 1078, 190 m); 5--sandy mud (St. 259, 140 m; St. 260, 183 m); 6--sandy mud on the slope whose sorting is poor (St. 631, 249 m). (For designations see fig. 33).

Key. St. 247 at 150 m, etc.

If the thickness of the upper layer increases (which is observed in depressions of the bottom), the graphic presentation does not have two apices. In areas where accumulation takes place, in the trench between Kanin Shoal (Kaninskaya banka) and Nurman Shoaling water (Murmanskoye melkovod'ye) (St. 749, 140 m; St. K 1342, 186 m) for instance, the cores up to 36 cm long did not reach the underlying layer; but a little to the north, in the area of erosion, which is associated with the Nordkapp Current (St. 1078, 190 m), a core sample 27 cm long contains, beginning from 16 cm, a dense and heavy, rosy-gray clay with fragments of shells. On the surface of clay lies a mixed material - interlayers and coatings of greenish-gray sand; beneath it, irregular areas of greenish-gray muddy sand and rosy-gray clay. At a depth of 12 cm from the top one can find pure muddy sand with shingle, including, at 8-10 cm, rounded shingles of sandstone (3 cm in diameter) with a slightly burnt surface having traces of fouling (fig. 45).

Slightly saline rosy-gray clayey mud (or clay) has been found at the eastern end of the Murman Trench (Murmanskiy Zhelob) (St. 628) where the thickness of the contemporary muddy sand equals 25 cm. On the surface of the lower layer lies an interlayer consisting of white, well-sorted rounded grains of quartziferous sand with an admixture of feldspar and ferrous minerals.

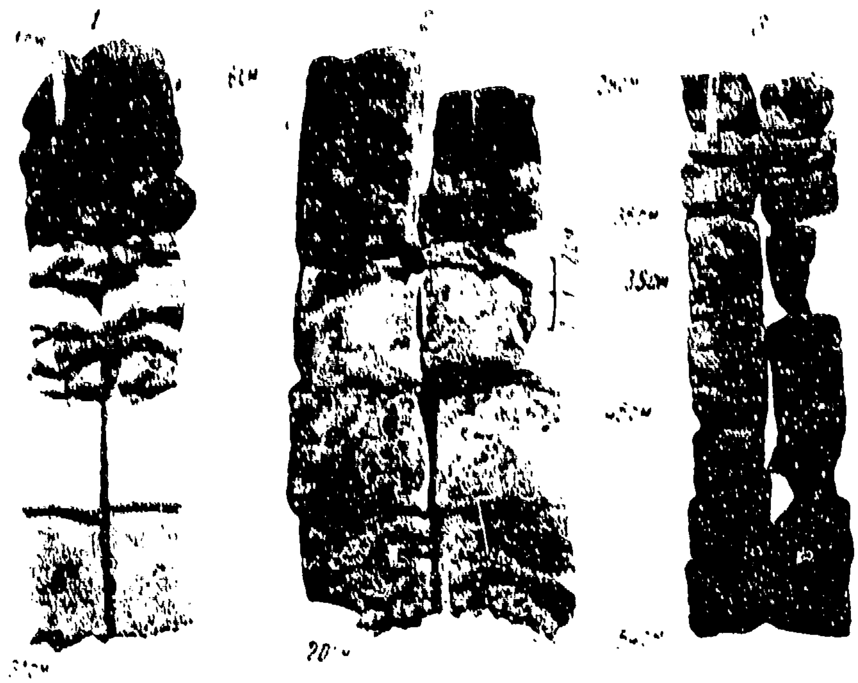

Fig. 45. Composition of the slope of Kaninskaya banka and Murmanskaya banka (Kanin and Murman Shoals).

1--Kanin Shoal (Kaninskaya banka) (St. 1078, 190 m). Column 31 cm long: 1 to 11 cm — muddy sand with shingle and gravel; 12 to 15 cm — areas of greenish-gray muddy sand and rosy-gray clay; 16 to 31 cm — rosy-gray clay; 2--The slope of the Murman Shoal (Murmanskaya banka) extending toward the Central Depression of the Barents Sea (St. 631, 249 m). Cores 6 to 20 cm long — irregular patches of greenish-gray muddy sand and gray mud; a layer of greenish-gray muddy sand at 14 cm and at 17 to 18 cm; beneath it, gray mud; 3--A layer of rosy-gray clay at 36 to 44 cm of the core between the layers of greenish-gray sandy mud. The beveled surface of separation at a depth of 44 cm (the core at St. 1535, 272 m at a depth of 29 to 54 cm of the core).

The underlying layer at the northwestern end of the Southern Murman Shoal (Yuzhnaya Murmanskaya banka) (St. 259, 140 m) has an analogous character; it lies 11 cm deep and contains an admixture of gravel. Above it lies an intermediary layer, but at a depth of 7 cm of the core, beneath the layer of muddy sand, lies an interlayer consisting of medium sized and coarse gravel made of rounded grains of schist and sandstone.

At great depths (St. 260, 183 m) the underlying layer lies beneath a core 34 cm long and has a slightly lumpy structure with thin layers of sand marking individual strata as the sample becomes dry. In the same depression, farther to the west (St. 262, 190 m) the thickness of the upper layer is 21 cm, but the lower layer consisting of rosy-gray clayey mud is very dense and uniform; it is separated from the upper layer by a thin sand coating containing grains of gravel. At St. 1068 (195 m) located on the same coordinates, the lower layer lying under the cover of contemporary sediments 18 cm thick has a rather different composition.

Still greater differences has the underlying layer in the northern part of the Murman Bank (Murmanskaya banka). Here, for instance at St. 1066 (165 m), under the surface layer having the usual composition and being 7 cm thick, lies a layer of gray, bright mud which is slightly carbonized and contains rounded grains of gravel mixed with mica and ferrous minerals. It is separated from the contemporary sediment by a transitional layer consisting of gravel and shingle of red granite. Still farther to the north, near the slope of the Central Depression, where

the thickness of the contemporary sediment is 11 cm (St. 261, 210 m), 5 cm (St. 1064, 217 m) and 7 cm (St. 631, 249 m), the underlying layer is represented by a gray dense and heavy mud or clay, which is slightly brackish and bubbles slightly from acids. The clay contains grains of gravel consisting of calcareous shale up to 1 cm in diameter; evidently, it represents the remnants of disintegration of the underlying rocks. The stratification of sediments of St. 631 on the slope of the Central Depression is analogous to the core 1078 (fig. 45, 1). Between the underlying layer and the contemporary sediments, which represent a typical case of erosion, is observed a transitional layer in the form of irregular patches of greenish-gray sandy mud and, beneath it, a gray layer with a slightly rosy-colored hue.

A complex stratification has also been observed on the northwestern spur of the Murman Bank (Murmanskaya banka) (fig. 46) where the thickness of the upper layer decreases at places to 2 cm (St. 2905, 272 m); at other places one can find rosy-gray clay lying between two layers of contemporary greenish-gray sandy mud (St. 1535, 272 m; fig. 45, 3).

Table 7

MEAN MECHANICAL COMPOSITION OF SEDIMENTS

Bottom Type	Fragments <0.01 mm in %	Depth in m		Fragments in mm					Number of Analyses
		from-to	mean	>1	1-0.1	0.1--0.05	0.05--0.01	<0.01	
Murman Shoal (Murmanskaya banka)									
Sand	<5	120-165	135	(0,8)	42,7	49,3	5,2	2,8	6
Muddy Sand	5-10	140-217	135	(3,8)	21,9	60,8	10,5	6,8	11
Sandy Mud	10-20	140-249	192	(1,1)	17,6	54,7	15,7	12,0	13
" "	20-30	195-300	262	(0,2)	2,6	46,6	26,5	24,3	4
The Area of the Western Commercial Shoals (Zapanyye promyslovyye banki)									
Muddy Sand	5-10	202-299	259	(6,0)	29,8	48,6	14,2	7,4	8
Sandy Mud	10-20	215-333	280	(2,8)	8,6	52,5	23,7	15,2	46
" "	20-30	222-322	281	(0,7)	3,4	35,0	36,5	25,1	18
Mud	30-40	230-365	299	(0,6)	2,3	34,6	28,2	34,9	7
"	40-50	——	262	(2,0)	6,1	17,7	29,5	46,7	1

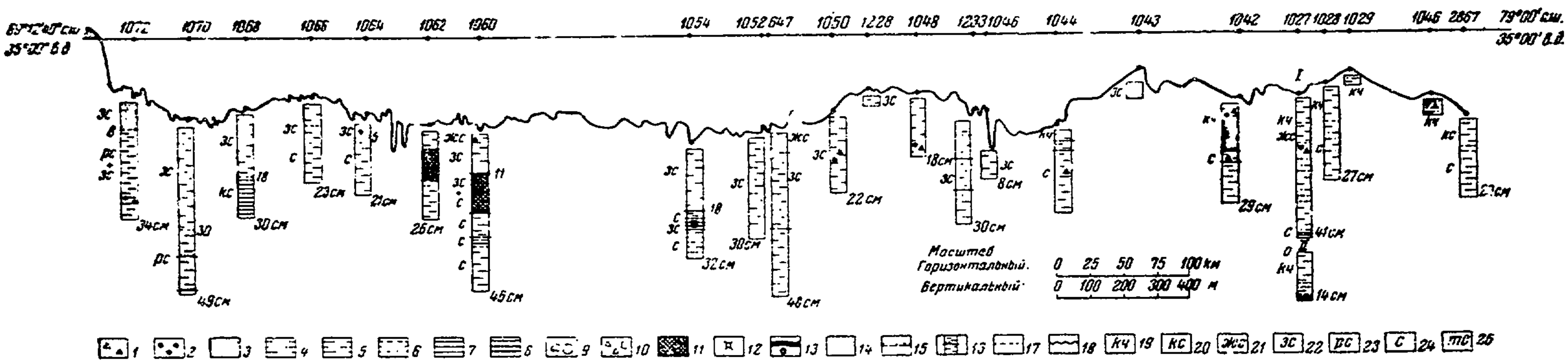

Fig. 46. Cross section along the Meridian 35°:

1--shingle; 2--gravel; 3--sand; 4--muddy sand; 5--sandy mud; 6--mud; 7--clayey mud; 8--clay; 9--shells; 10--broken shells; 11--mixture of sandy mud and mud; 12--rhizopods; 13--ferrous interlayers; 14--sandy interlayers; 15--clay coatings; 16--fragments; 17--borders of layers; 18--uneven (rough, Tr.) surface; 19--pink color; 20--pinkish-gray; 21--yellowish-gray; 22--greenish-gray; 23--rosy-gray; 24--gray; 25--dark gray.

Key: The upper horizontal lines (from left to right): Lat. 69°12'40" N........Lat. 79°00' N.
Long. 35°00' E...........Long. 35°00' E.

(Right Center) Scale
Horizontal 0 - 100 km
Vertical 0 - 400 km

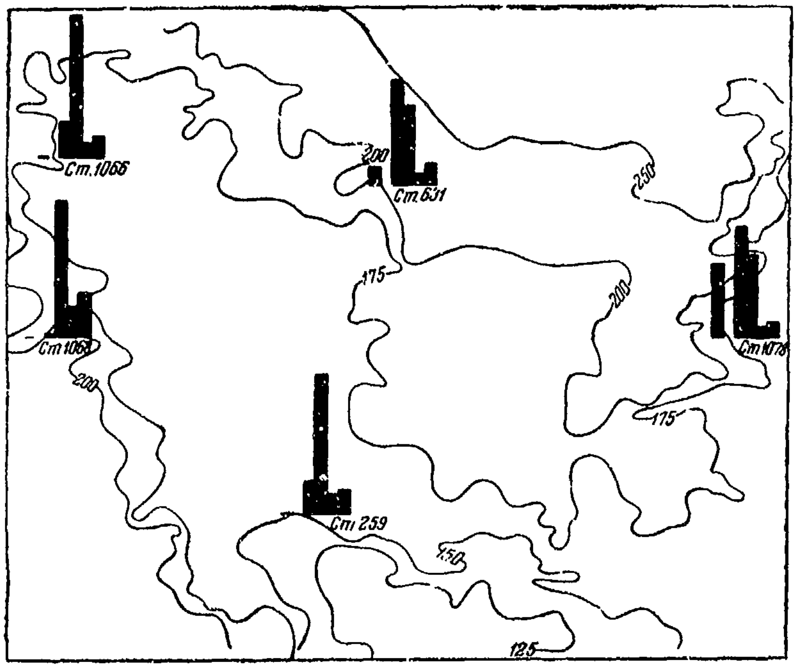

Fig. 47. Distribution of sediment types on the surface of the Murman Bank (Murmanskaya banka) according to mechanical composition (For designating symbols see fig. 33).

Thus the Northern and Southern Murman Shoals (Severnaya, as well as the Yuzhnaya, Murmanskaya banka) represent a surface submerged beneath the sea level, on which the thickness of contemporary sediments is measured in centimeters (fig. 46, St. 1064-1068). Obviously, all the surface was covered by Quaternary deposits which cover the original rocks of varying composition. This causes certain differences in the composition of the lower layer of cores, whereby individual diversities can be well detected in the southeast-northwest direction of the shoals as they change with locality; this is in complete agreement with our concepts on the geological structure of the given area of sea bottom. The lower layers of the cores taken from the Murman Bank (Murmanskaya banka) should be subjected to a special investigation and more powerful instruments be used in the collection of samples in order to obtain data for the original rocks composing the area.

The presence of washouts resulting from the action of sea currents on on the slopes of the shoal, which is reflected in the types of sediments (fig. 47), is also confirmed by the mean mechanical composition (table 7) in which the curve representing the content of sand particles ranging from 1 to 0.1 mm forms a pronounced bend, but the coarse silt sharply increases in the interval of muddy sand (fig. 35). The washout is indicated by the absence of a direct relation between the depth and mechanical composition.

6. The Area of the Western Commercial Shoals
(Zapadnyye promyslovyye banki)

The area located to the north of the Nordkapp Trench consists of a system of elevations at depths ranging from 250 to 350 m, which separate the Nordkapp Trench from the western Medvezhinskiy Trench. To the northeast and east, a smooth surface of the Central Plateau /135
separates the area from the Central Elevation and the Central Depression. The roughness of relief in the area is associated with the extreme western spurs of folds of the Kanin-Timan system which reach the area. Here the folds are cut by a caving in the Western Trench, and their direct continuation westward is interrupted. The area includes the commercial shoals - Demidovskaya and Cherkova Shoals as well as the northern slope of the Nordkyn Shoal (Nordkinskaya banka). Farther to the west, the system of elevations includes, of course, the Kopytov Shoal (Kopytovskaya banka) described by P. S. Vinogradova (1957).

The bottom relief in the area of the Western Commercial Shoals (Zapadnyye promyslovyye banki) is characterized by a relative complexity. The elevations are intersected by trenches which to the north and northwest, in the majority of cases, descend toward the Medvezhinskiy (Bear) Trench. Because the area is situated at great depths, the

sediments, despite the indentation of relief, are at the first glance uniform;[1] the sandy mud containing 10 to 20% of fragments <0.01 mm predominates.

On elevations and steep slopes one can find sand which is usually not well sorted and contains a large proportion of fragments ranging from 1 to 0.1 mm. Mud is also found in locked relief depressions but more frequently in areas from which old sediments have been eroded. Therefore it [mud] is frequently found at smaller depths than in the case of sandy mud; its mechanical composition is represented by a graph having two apices.

In the western part of the area (along the cross section Cape Nordkapp-Bear Island [Bjørnøya] fig. 32; St. 1137 to 1879, at depths ranging from 277 to 354 m) the bottom is covered by sandy mud whose cementation is weak in dry condition and which contains sponge spicules, carbonate /136 tests, a great quantity of microfauna-namely: foraminifera and ostracoda. At the extreme northern stations the oxidized layer is more pronounced and the upper section of cores has a pinkish-gray color.

[1]Data obtained during the following cruises of the survey ship Persei (Persey) were used: 12th cruise in 1927, 45th in 1933, 50th in 1934, by T. I. Gorshkova; 19th in 1929 by K. R. Olevinskii; 27th in 1930 by A. S. Ruchik; 28th in 1930 by V. P. Zenkovich; 35th in 1931 by L. A. Iastrebova and E. K. Kopylova; 40th in 1932 by V. P. Zenkovich and E. K. Kopylova; 43rd in 1933 by P. N. Novikov; 54th in 1935 by S. I. Malnin and Kuzovleva; 70th in 1938 by O. N. Kiselev; and during the 48th cruise of survey ship Knipovich in 1934 by S. I. Malnin.

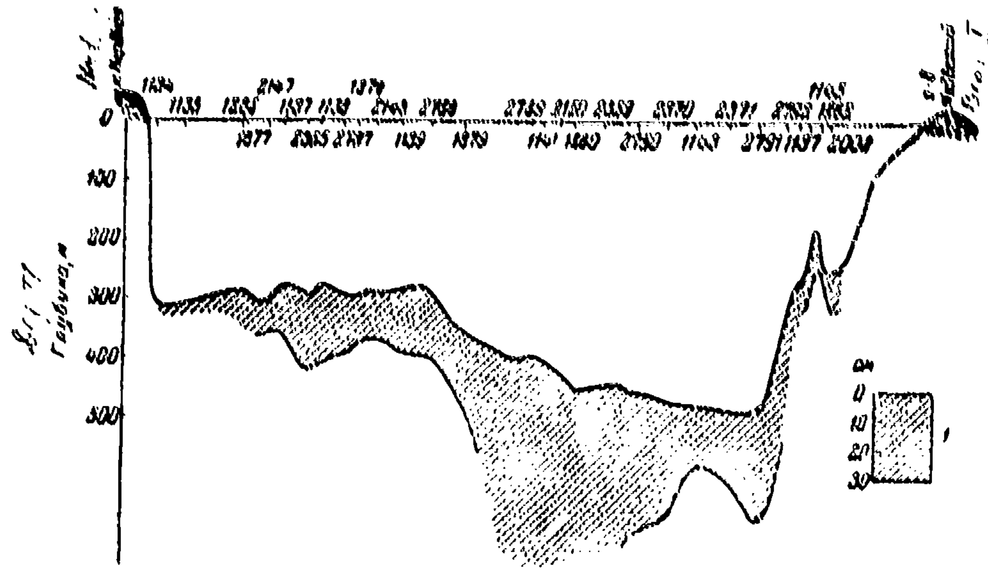

Fig. 48. Changes in the thickness of sediments along the cross section Cape Nordkapp-Bear Island (Bjørnøya):

1 - contemporary sediments (thickness of layer in centimeters).

Key. The upper left-hand corner: Nordkapp
The upper right-hand corner: Bear Island
The vertical line, left: Depth in m.

Cores consisting of two layers had been found almost throughout the cross section. Under the upper layer of yellowish-gray sandy mud with carbonate remains, mica and individual large rounded grains of quartz one can find mud or clayey mud having a gray or bluish-gray color, sometimes with a rosy-colored hue, which is well cemented in dry condition and contains a considerable admixture of gravel and shingle. The thickness of the upper layer ranges from 15 to 30 cm (fig. 48). The transition to the lower layer is in the majority of cases completely clear and marked by an interlayer of sand which is sometimes very thin, having a character of coating. In the western part the variation in the thickness of the upper layer is negligible (table 8).

Definite decreases in thickness can be observed on bottom elevations (at Stations 1137 and 1878, for instance). Sometimes the yellowish-gray and greenish-gray sandy mud lends a rosy-colored hue at 3 to 4 cm beneath the surface, preserving still its mechanical composition. At Stations 1139 and 2787 the transition from the upper layer of the sandy mud to the lower layer of clayey mud occurs gradually, but under the clayey mud appears once more a coarser sediment.

At Stations 1137, 2365 and 1138 the lower layer has a rosy-gray color. It is everywhere dense, sometimes bubbling from acids (Stations 1137 and 2140); at all stations the layer contains a greater or smaller quantity of gravel. Among coarse grains one can also find dark-gray clayey schist, detritus (scheben') of plagioclase granite and orthoclase shingle (red), but farther to the east, also quartzite and

siliceous schist. To the east, at a depth of approximately 300 m, the depth is covered with the same sandy mud as in the cross section Cape Nordkapp-Bear Island (Bjørnøya); it has an increased quantity of coarse silt particles (62.5 to 65%; fig. 49), whose mechanical composition is /137
sometimes expressed by a graph with two apices.

Table 8

THICKNESS OF CONTEMPORARY DEPOSITS ON THE SOUTHERN SLOPE OF THE WESTERN TRENCH

Station	Depth in m	Length of columns in cm[1]	Thickness of contemporary sediment in cm	Character of transition
1137	277	21	16	Pinkish-red color
1137	277	34	22	Yellowish-gray color; uneven surface
2365	300	73	25	Admixture of sand
1138	282	45	20	—
1138	282	45	26	Uneven surface
2787	297	72	21	Gradual
2787	297	100	20	Pinkish-gray color
2148[2]	290	88	16	Inclusions of partly dissolved shells
1878	288	31	15	Mixing of the upper and lower layers
1139	281	44	22	Gradual
1139	281	43	30	Shifts in color and density
2788	280	46	21	Uneven surface
1879	354	31	25	Admixture of sand; grains of gravel

[1]The length of cores is always given in dry condition.
[2]The sample was taken by the Ubekochernaz bottom core.

At smaller depths here is found mud related to sandy mud (St. 315, 230 m). According to T. I. Gorshkova, the upper 30 cm of the core are represented by a mixture of greenish-gray and violet-gray particles, but the lower 30 cm consist of violet-gray (rosy-gray. — M. K.) mud (T. I. Gorshkova, 1931). Such a composition of sediments representing a product of erosion of the underlying layer is confirmed by graphical presentation of mechanical composition - namely by the two apices (fig. 49, 2).

The underlying layer of the area is represented by a dense rosy-gray mud related to clayey mud and containing a considerable quantity of carbonate sediments, calcareous rhizopods, gravel and shingle. On Demidovskaya banka (Demidov Shoal) in the northeastern part of the area (St. 1541, 286 m), under the contemporary layer of sandy mud 19 cm thick lies a layer of clayey mud 20 to 35 cm thick, which has a rosy-colored hue, and a very dense and heavy layer of clayey mud 36 to 53 cm thick, which is firmly cemented in dry condition and has a pinkish-gray color.

As can be seen from data by O. N. Kiselev obtained in 1938, on the Demidov Shoal (Demidovskaya banka) each type of mechanical composition is restricted to definite conditions of hydrological regime and bottom relief. Muddy sand occurs on the surface and slopes of underwater elevations at depths ranging from 202 to 299 m and in areas characterized by abrupt variations in depth. Sandy mud, related to muddy sand, whose graphical presentation of mechanical composition is characterized by one apex and which is well sorted, extends in a belt from the west to the east (fig. 50), merging with the western slope of the Central Plateau

and coinciding with the basic course of one of the branches of the Nordkapp Current. A variant of the type of sandy mud containing a large quantity of sand and being less clearly assorted is restricted to the slope of the Medvezhinskaya Depression (Medvezhinskaya vpadina), to individual projections of isobaths and to isolated shoals which, obviously, constitute the source of fragments ranging from 1 to 0.1 mm.

In relatively calm areas at depths ranging from 270 to 318 m, the under water trenches protected from the east by elevations are covered by sandy mud containing an increased amount of fragments smaller than 0.01 mm and, lastly, the wide level areas and gentle slopes are covered by a sandy mud, which is nearly like mud and has a maximum of fine silt particles, i.e. having the symptoms of cementation or the same type of mud. The type of mud contains also sediments having almost equal quantity of fine silt and pelite (fig. 50) which is restricted to the depths of approximately 300 m and, as suggests A. S. Vinogradova (1957), is possibly associated with the accumulation of mud particles in the areas characterized by an intense growth of siliceous sponges.[1]

[1] A thorough examination of sediments that appear to be uniform at the first sight enables us to find an explanation of all the characteristics of their mechanical composition and it confirms the fact that the latter is the most sensitive indicator of all the variations, even the insignificant ones, in the hydrodynamical regime. Analyses of samples made in 1947 on the survey ship Saratov confirmed the presence of all the types that could be singled out from the materials collected in 1938.

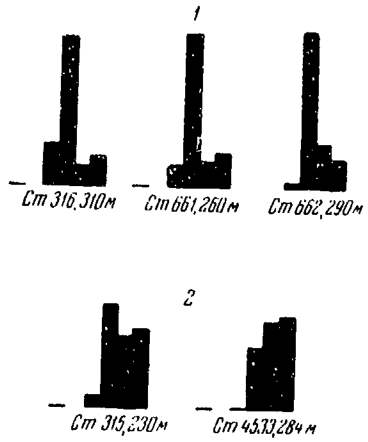

Fig. 49. Mechanical composition of sediments in the area of the Western Commercial Shoals (Zapadnyye promyslovyye banki):

1--sandy mud (St. 316, 310 m; St. 661, 260 m; St. 662, 290 m); 2--mud (St. 315, 230 m; St. 4533, 284 m).

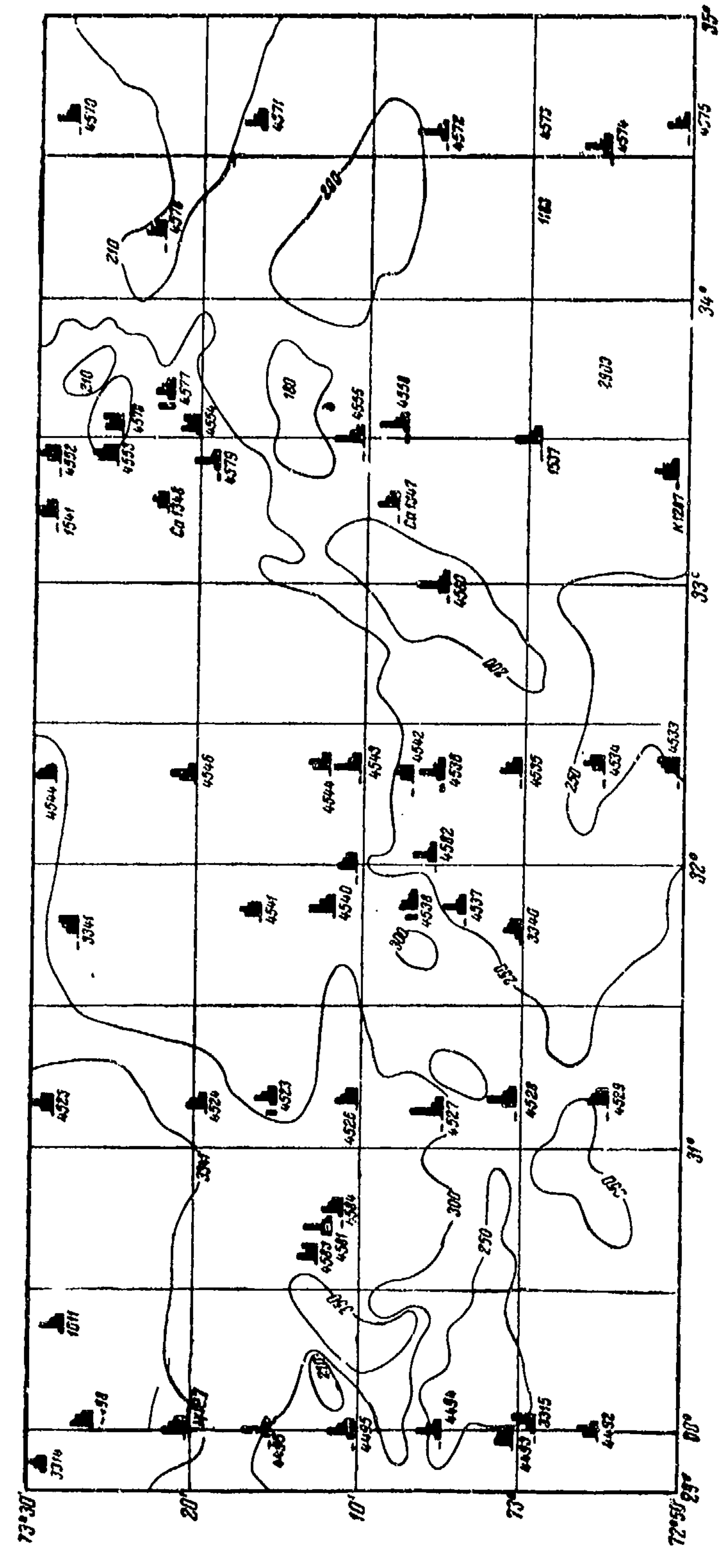

Fig. 50a. Types of mechanical composition of sediments on the Demidov Shoal (Demidovskaya banka) (For explanation of symbols see fig. 33).

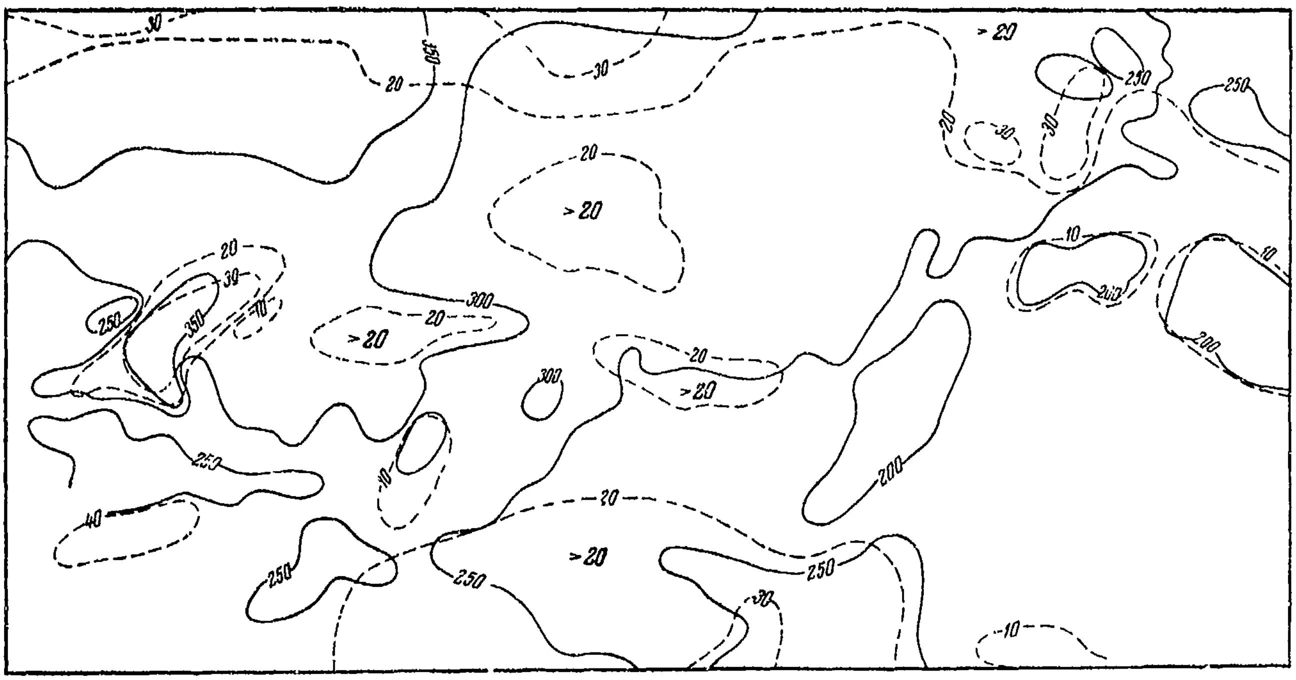

Fig. 50b. Fragments smaller than 0.01 mm on the Demidov Shoal (Demidovskaya banka). Isolines in %.

In connection with the complex character of bottom relief in the area of the Western Commercial Shoals (Zapadnye promyslovyye banki), the graph expressing the mean mechanical composition (table 7) has a graduated form reflecting the various sources of material that is subject to sorting.

7. The Pechora Shoal
(Pechorskoye melkovod'ye)

The southeastern part of the Barents Sea, the so-called Pechora Sea (Pechorskoye more) is a shoaling water region with a level and smooth bottom. To the south it adjoins the eastern part of Chëshskaya Bay (Ch. Guba) the estuary of Pechora, Khaypudyr Bay (Khaypudyrskaya Guba), to the east it is bounded by Vaygach Island (ostrov Vaygach), to the west by Kolguyev Island (ostrov Kolguyev). The northern boundary runs along the 100 meter isobath separating the Pechora Shoal (Pechorskoye melkovod'ye) proper from the Trench of Novaya Zemlya (Novozemelskiy Zhelob). To the east the boundary between the Pechora Shoal (Pechorskoye melkovod'ye) and the Kanin-Kolguyev (Kaninsko-Kolguyevskiy) area runs near the long. 50° E.

Because the Pechora Shoal (Pechorskoye melkovod'ye) being a continuation of the Pechora Depression on the bottom of the Barents Sea, is covered by a very thick layer of sediments, the bottom relief has been smoothed and the depths increase gradually. The 50-m isobath lies at a distance of 80 to 100 km from the coast. An identical gentle slope is observed toward the 100-m isobath, and only at a depth of about 70 m does the

slope increase a little, but the mean angle of inclination does not exceed 4 minutes (M. V. Klenova, 1931).

The isobaths drawn at each 10 meters (fig. 51) enabled us to notice certain characteristics of this sloping bottom relief. Thus, the projection of the 20-m isobath to the southeast of the Gulyayevskiye Koshki Islands (ostrova Gulyayevskiye Koshki) delimits the gradual slope, which is evidently the old bed of the Pechora River, running at first along Dolgiy Island (ostrov Dolgiy), then toward the northwest. Along the east coast of Kolguyev Island (ostrov Kolguyev) (fig. 14) the isobaths reflect its former limits which have been spread out as a result of thawing of permafrost and of thermal abrasion. A gradual elevation extends from Cape Russkiy Zavorot (Mys Russkiy Zavorot) to the northwest, embracing the present day Kolguyev Island (ostrov Kolguyev).

In connection with small depths, smooth bottom and an active hydrodynamical regime associated with waves and tidal currents, the bottom within the limits of the 20-m isobtah is covered with sand having an admixture of gravel and shingle.[1]

[1] The data obtained during the following cruises of the survey ship Persei (Persey) have been used: 4th cruise in 1924 by T. I. Gorshkova; 8th and 10th in 1925, 14th in 1927 by M. V. Klenova; 49th in 1934 by P. N. Novikov; 80th in 1939 by O. N. Kiselev; of the survey ship Knipovich: 48th cruise in 1934 by S. I. Malinin and 52nd in 1934 by N. N. Khokhlin; of the survey ship Poliarnaia Zvezda: 3rd cruise in 1934 by A. F. Val'nev; and several stations of the survey ship Kashalot on the 11th cruise in 1945 by Turpaeva.

As the depth increases the sand is replaced by muddy sand and sandy mud. The tiniest minute particles, i.e. the sandy mud, bordering on mud, is deposited in the Zakolguyev area where in the calm area, which is sheltered by the Kolguyev Island (ostrov Kolguyev) and the shoaling water surrounding it, muddy erosional products of the Quaternary clay of Kolguyev are accumulating. A belt of sandy mud extends northward merging with the sandy mud of the Pre-Novaya Zemlya Trench (Pri-Novo-Zemelskiy Zhelob). The sandy mud also is found between the Dolgiy Island (ostrov Dolgiy) and the continent at the entrance to the Khay-pudyr Bay (Khaypudyrskaya Guba).

The sand of the Pechora Shoal consists predominantly of quartz and is cleanly washed, containing a noticeable admixture of feldspar and magnetite. The coarse grains are smooth. The color is yellowish-gray. The sand contains a considerable quantity of ocherous particles, chitin tubes and burrows of worms, many carbonate fragments and whole shells. In the northwestern part of the area the sand is enriched with broken and whole shells of *Astarte* sp., *Cardium* sp., *Mytilus edulis*, fragments of barnacles (St. 129, 29 m; St. 131, 66 m; St. 2747, 95 m). Also calcareous rhizopods and spines of sea urchins are found; at places accumulations consisting almost exclusively of shells are formed.

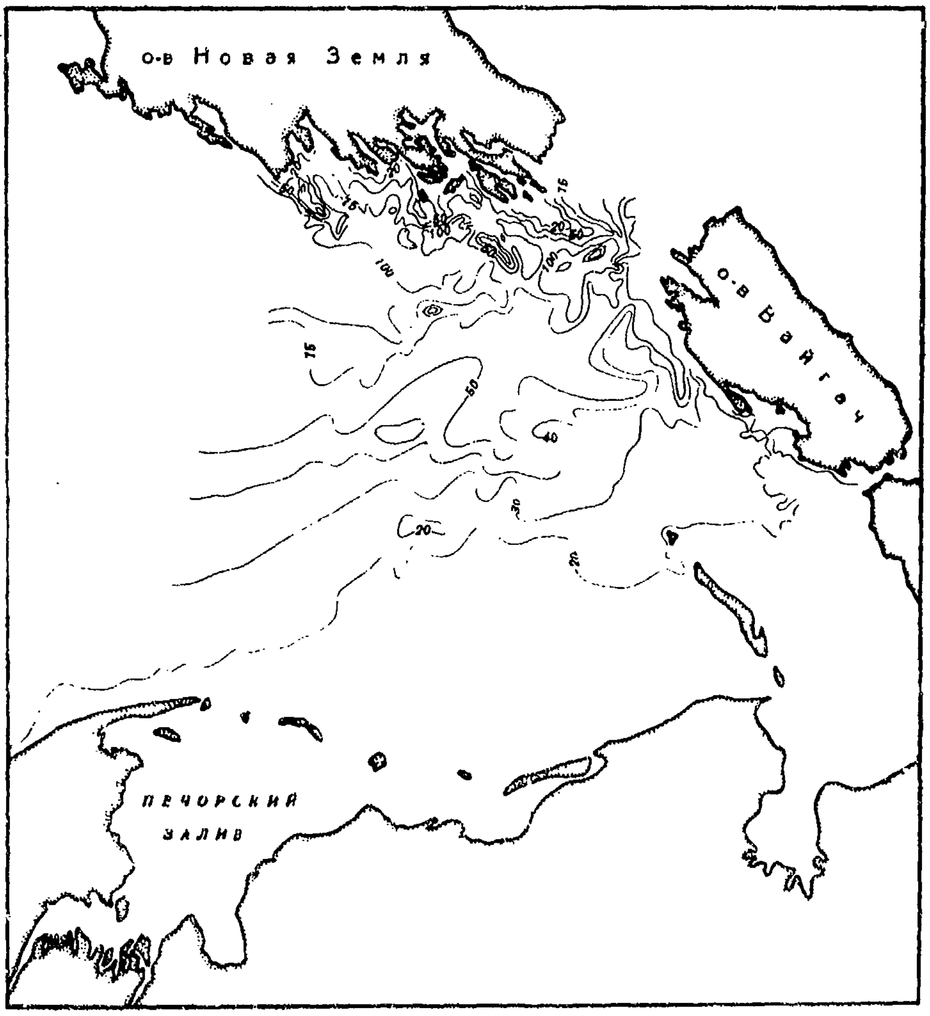

Fig. 51. Bathymetric Chart of the Pechora Shoaling Waters (isobaths at 10 m).

Key. From top to bottom (clockwise): the Novaya Zemlya Island (ostrov Novaya Zemlya) - the Vaygach Island (ostrov Vaigach) - the Pechora Gulf (Pechorskiy Zaliv).

Here, in the sand, a considerable admixture of gravel and fragments of rocks have been found. Near Cheshskaya Bay (Cheshskaya Guba) one can even visually detect an apparent concentration of heavy minerals in the sediment, such as magnetite and garnet, as well as fragments of basalt (St. 504, 23 m). Near the estuary of the Pechora the sand has a pink color, (St. 382, 22/18 m). On the basis of mechanical composition one can discriminate between fine and average sand with smooth or partly smooth grains (St. 140, 15 m) and silty sand characterized by a high degree of sorting where the quantity of coarse silt reaches 85% (St. 506, 23 m; St. 384, 20 m; fig. 52).

In the muddy sand one can also distinguish two variations - namely: poorly sorted muddy sand with a considerable amount of fragments ranging from 1 to 0.01 mm, the graph of its mechanical composition has sometimes two apices; this type is found in the central section of the area at a projection of the 50-m isobath to the north of the estuary of Pechora (St. 145, 52 m; St. 393, 52 m); it contains a considerable quantity of gravel and shingle consisting of fragments of schist, rosy-colored sandstone and basalt, as well as organic remains, such as fragments of mollusks, echinoderms, worms tubes (chitin and sand): Spiochaetopterus typicus, Maldane sarsi, barnacles, Hyperammina subnodosa. Farther to /142 the east the muddy sand is represented by the other variant characterized by a high degree of sorting (St. 391, 32 m), notably in the southern part of the region, off the entrance to Cheshskaya Guba (St. 533, 40 m) in an area affected by strong tidal currents (fig. 52).

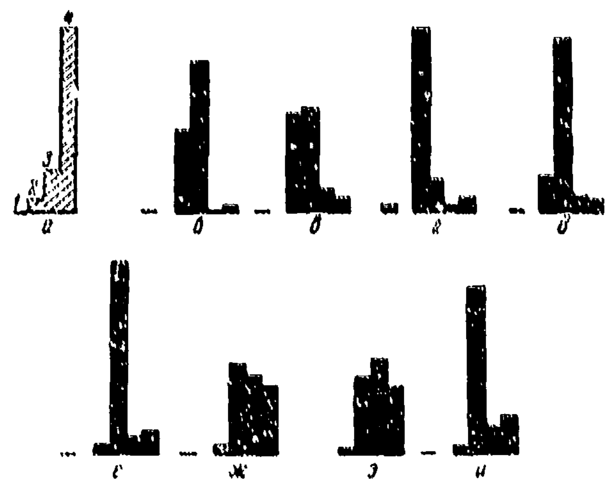

Fig. 52. Types of mechanical composition of sediments on the Pechora Shoaling Waters(Pechorskoye melkovod'ye).

a,б --silty sand (a — St. 506, 23 m; б — St. 384, 20 m); в, г --muddy sand, badly assorted (в — St. 145, 52 m; г — St. 393, 52 m); д ,e--muddy sand, well assorted (д — St. 391, 33 m; e — St. 533, 40 m); ж ,3,u--sandy mud (ж— St. 155, 50 m; 3 — St. 154, 64 m; u — St. 147, 39 m). For explanation of symbols see fig. 33.

The sandy mud has a very similar composition. Along the coast (St. Ka 371, 38 m; St. Ka 370, 48 m; fig. 53) to the southeast of Kolguyev Island (ostrov Kolguyev) it contains as much as 57% of particles ranging from 1 to 0.1 mm. To the east of the Kolguyev Island (ostrov Kolguyev) the quantity of sand particles decreases (St. 155, 50 m; St. 156, 47 m; St. Ka 375, 45 m), but at great depths appear evidence of cementation, a maximum [quantity of sand] being reached in the fine silt (St. 154, 64 m; fig. 52), whereas nearer to the island a maximum is preserved in the coarse silt (St. Ka 381, 54 m; St. Ka 382, 73 m; fig. 53) at a certain increase in the content of sand particles.

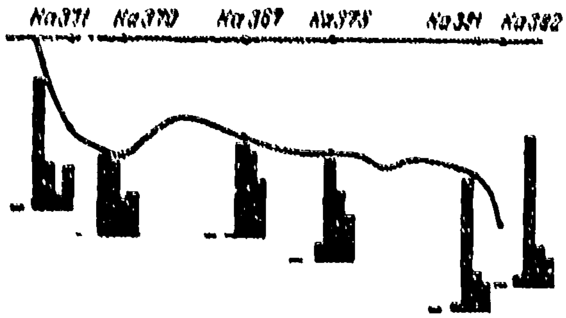

Fig. 53. Changes in the mechanical composition of sandy mud in the coastal belt (Stations Ka 367 through Ka 382). For explanation of symbols see fig. 33.

The sandy mud of the Pechora Shoal (Pechorskoye melkovod'ye) has a greenish-gray color, sometimes with a slightly yellowish hue in the upper layer. The amount of organic remains is small, increasing a little toward the south of the Kolguyev Island (ostrov Kolguyev) where, in addition to broken shells, rhizopods Hyperammina subnodosa, tubes of worms, small shells of Nucula tenuis, Astarte sp., Yioldia hyperborea have been found.

A considerable admixture of sand as well as the gravel and shingle consisting of gray and rosy-colored sandstone, quartz and basalt is found in the sandy mud (St. 138, 60 m; St. 151, 68 m) lying near a steep underwater shelf in a trench to the east of ostrov Kolguyev (St. 395, 69 m), as well as in the Khaypudyr Gulf (Khaypudyrskaya Guba) (St. 388, 13 m; 54.2% particles ranging from 1 to 0.1 mm) where also gravel, consisting of light-gray quartzite and dark-gray sandstone, is found. In the central section of the shoal water, near the belt covered with muddy sand whose mechanical composition is characterized by a graph having two apices, near the projection of the 50-m isobath, an identical graph can also be constructed on the basis of sandy mud (St. 147, 39 m; fig. 52).

Data concerning the contemporary sediments are not at our disposal because the few short cores have nowhere reached the underlying layer.

As was already observed in the Kanin-Kolguyev area, with the presence of smooth bottom and the absence of erosion material from underwater elevations, the graph of mechanical composition (table 9) presents an almost rectilinear relation between the number of particles ranging from 1 to 0.1 mm and from 0.05 to 0.01 mm and the number of particles smaller than 0.01 mm; only a negligible increase in the quantity of particles ranging from 0.1 to 0.05 mm is observed in the interval containing muddy sand (fig. 43).

Table 9

THE MEAN MECHANICAL COMPOSITION OF SEDIMENTS

Bottom type	Fragments <0.01 mm in %	Depth in m		Fragments in mm					No. of Analyses
		from-to	mean	>1	1-0.1	0.1--0.05	0.05--0.01	<0.01	
Pechora Shoaling Water									
Sand	< 5	3-79	38	(1,4)	42,6	48,5	6,0	2,9	11
Muddy Sand	5-10	45-105	44	(3,6)	35,4	49,5	7,8	7,3	20
Sandy Mud	10-20	13-98	51	(1,7)	20,6	47,2	17,5	14,7	29
" "	20-30	30-72	48	(0,4)	10,2	34,4	30,8	24,6	9
Goose Bank (Gusinaya banka)									
Sand	< 5	112-245	171	(0,4)	53,0	38,3	5,4	3,3	9
Muddy Sand	5-10	114-192	158	(3,0)	34,9	48,2	9,8	7,1	9
Sandy Mud	10-20	125-259	181	(1,7)	27,8	40,6	18,3	13,3	11
" "	20-30	— —	262	(0,4)	5,6	45,4	24,0	25,0	1
Mud	30-40	249-288	268	(0,5)	5,8	29,8	29,0	35,4	2
Central Plateau									
Muddy Sand	5-10	208-256	237	(4,7)	17,5	56,4	18,5	7,6	4
Sandy Mud	10-20	212-294	241	(1,6)	12,1	52,1	20,5	15,3	14
" "	20-30	238-326	274	(3,6)	4,2	41,8	29,0	26,0	18
Mud	30-40	231-373	248	(0,2)	0,6	22,6	42,6	34,2	3

8. The Goose Bank

(Gusinaya banka)

In addition to the Goose Bank (G. Banka) proper, the area includes part of the shoal water lying between it and the Goose Land Peninsula (poluostrov Gusinaya Zemlya), the tongue of sea from a depth of 200 to 250 m having a complex bottom relief and sloping steeply toward the Central Depression of the Barents Sea, and the trench dividing the Goose Bank (Gusinaya banka) and Kanin-Kolguyev Shoal (Kaninsko-Kolguyevskoye melkovod'ye) which we shall name the Goose Trench (Gusinyy Zhelob). /144

The surface of the Goose Bank (Gusinaya banka) at a depth of 70 m belongs to the type of denuded underwater plains (V. P. Zenkovich, 1938). The system of sloping elevations (whose relative height does not exceed 150 to 200 m according to the Russian definition of the term "uval", Tr.) and small round troughs that have been detected during detailed depth measurements is similar to the surface of the coastal platform of the Goose Land Peninsula (poluostrov Gusinaya Zemlya). In addition to the Goose Trench (Gusinyy Zhelob), which represents a clearly pronounced trench extended in an almost east-west direction, the slopes of the Goose Bank (Gusinaya banka) are intersected with trenches of a smaller size, which are especially clearly pronounced at depths ranging from 70 to 180 m on the western and northern slopes. In the northwestern part of the Goose Bank (Gusinaya banka) at a depth of 180 m there is a well pronounced underwater terrace with outcrops of original rocks and a great number of large boulders (M. V. Klenova, 1931). A thorough analysis of

relief shows that this terrace with several fluctuating depths can be traced throughout the Barents Sea.

The smooth surface of the Goose Bank (Gusinaya banka) is covered by boulders, detritus, shingle broken and whole shells.[1] Sometimes poorly sorted sand with gravel is found and there are indications that old clay is being exposed on sloping depressions on the surface of shoals and on their steep slopes. However, according to the cores that are at our disposal and whose lengths reach 57 cm, the average being about 20 cm, the underlying layers are not denuded. V. P. Zenkovich (1938) considers the sediments lying on the Goose Bank (Gusinaya banka) to be a protective covering that shields the deeper layers from erosion. The region of the broken relief on the northern and western slopes of the shoal is also covered predominantly by coarse fragments. The chief active hydrodynamical factor on the surface of the Goose Bank (Gusinaya banka) is the waves generated by the prevailing northerly winds.

The western part of the region, i.e. the northern slope of the Kanin Shoal (Kaninskaya banka) and the western slope of the Goose Bank (Gusinaya banka), is subject to the action of a strong branch of the Nordkapp Current whose depth at this place is approximately 200 m and which, passing by the slopes of shoals, causes an accumulation of coarse

[1] The data obtained during the following cruises of survey ship Persei (Persey) were used: 6th cruise in 1924, 13th in 1927, by T. I. Gorshkova; 8th in 1925, 18th in 1929 by M. V. Klenova; 27th in 1930 by A. S. Ruchik; 46th in 1933, by V. M. Ratynskii; during the following cruises of survey ship Knipovich: 48th in 1934 by S. I. Malinin and 52nd in 1935 by N. N. Khoklin.

grained sediments. Relatively protected areas are created in the western part at a depth of approximately 250 m and in isolated pits of the Goose Trench (Gusinskiy Zhelob), as well as at its eastern end.

On the slopes of the Goose Bank (Gusinaya banka) the coarse sized material is replaced by sand which in the east descends to a depth of 100 m but on the western spurs down to 220 m (St. 755). Further, to a depth of 200 m the bottom is covered with muddy sand which at a depth of about 250 m merges with sandy mud. The bottom of the Goose Trench (Gusinyy Zhelob) is covered with sandy mud in its deepest section and in the section farthest from the Central Depression. In the western part of the trench, mud has been found.

The sand which occurs on the slopes of the Goose Trench (Gusinyy Zhelob) belongs to the category of silty sand, i.e. coarse silt particles prevail in the material. Its color is usually greenish-gray and it sometimes contains a considerable amount of carbonate remains of organisms or chitinous worm tubes. The particles ranging from 1 to 0.1 mm are represented by smooth quartz grains. Quartz together with feldspar constitutes also the remaining particles; besides, there occurs magnetite, and on the southern slope, mica (St. 366, 151 m). The character of the muddy sand is similar but on the northwestern spur of the Goose Bank (Gusinaya banka) (St. 2509, 161 m) and on the slope forming the Goose Trench (Gusinyy Zholob) (St. 2505, 145 m) it contains an admixture of calcareous rhizopods as well as gravel and detritus of gray schist. The quantity of mica is somewhat greater than in the sand. In some cores

lumps of mud have been found but everywhere the bottom is represented by a mechanical composition graph having one apex, which attests to the absence of erosion at the present time and to a great thickness of the protective layer of friable sediments. The character of the sandy mud is identical; it differs only by a more clearly expressed pinkish-gray color in the Goose Trench (Gusinyy Zhelob) (St. 776, 141 m; St. 243, 262 m). In connection with a high degree of iron oxidations in the sandy mud, ocher coatings occur frequently, especially around the tubes of worms. /145

The mud found in the pit of the western part of Goose Trench (Gusinyy Zhelob) (St. 1112, 288 m) has a lumpy structure and, based upon the mechancial composition graph, it is related to the sandy mud found at St. 243, 262 m in the same trench (fig. 54) but it contains a rather smaller quantity of coarse silt.

Because of an active hydrodynamical regime, the displacement of the material composing the friable protective covering takes place at the present time only on the Goose Bank (Gusinaya banka). Therefore, according to the quantity of fragments that are smaller than 0.01 mm, the graph representing the mean mechanical composition (table 9) contains small projections on the sand curve (1 to 0.1 mm) and bends for fragments ranging from 0.1 to 0.05 mm, which reflects the influx of a supplementary

Fig. 54. Mechanical composition: a--mud (St. 1112, 288 m); б--sandy mud (St. 243, 262 m). For explanation of symbols see fig. 33.

material (fig. 35, e).

9. The Central Plateau

The area of a relatively smooth bottom at a depth of about 250 m between the Murman Shoal (Murmanskaya banka) on the south, the Central Elevation on the north, and the area of Western Commercial Shoals (Zapadnyye promyslovyye banki) is called the Central Plateau. On the east its boundary runs between long. 38 and 39° E on the slope of the Central Depression of the Barents Sea.

Sandy mud prevails in the Central Plateau.[1] On the boundary with Murman Shoal (Murmanskaya banka) and the area of the Western Commercial Shoals (Zapadnyye promyslovyye banki) and on isolated bottom elevations, muddy sand was found, but near the Central Elevation, under the protection of its western spur, mud occurred. Almost everywhere on the surface of the plateau one can find fragments of rocks in the sediments; in the western portion of the area one can find tubes, and occasionally eroded shingle and its concretions covered by brown oxides.

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[1]Data obtained during the following cruises of survey ship Persei (Persey) were used: 12th in 1927, 17th in 1928, by T. I. Gorshkova; 18th in 1929 by M. V. Klenova; 27th in 1930 by A. S. Ruchik; 28th in 1930 by V. P. Zenkovich; 54th in 1935 by S. I. Malinin and Kuzovleva; during the following cruises of survey ship Knipovich: 24th cruise in 1931 by K. A. Rachkovska; 48th in 1934 by N. N. Khokhlin; in addition, the data obtained by P. S. Vinogradova during the 26th cruise of survey ship Issledovatel' in 1940 were used.

The muddy sand (at St. 1062, 256 m, for instance) has a yellowish-gray color; it contains a considerable admixture of gravel (fig. 55) many chitin tubes, carbonate remains, spicules, and calcareous rhizopods. The same compositional content, as well as the graphical presentation of /146 mechanical composition by one apex, characterizes the sandy mud in the northern (St. 640, 232 m; St. I 2212, 229 m) and southern (St. 1126, 294 m) portions of the region. A sandy mud, which was less well sorted and whose graphical presentation of mechanical composition was expressed by two apices (St. 1054, 310 m, etc.), occurred on the slope of the spur of Medvezhinskiy Trench penetrating into the Central Plateau south of the Central Elevation. At a smaller depth, nearer to the Central Elevation, sandy mud having a maximum of fine silt occurred; the quantity of individual fragments composing it was equally distributed (St. 1489, 246/252 m; fig. 55) as it was observed also in the level areas of the Western Commercial Shoals (Zapadnyye promyslovyye banki); also the character of mud was the same (St. I 2155, 231 m; St. I 2155, 239 m).

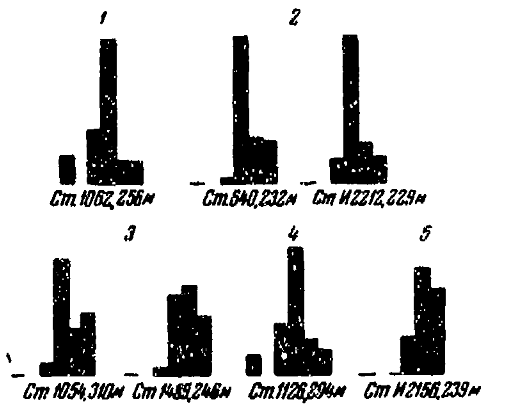


Fig. 55. Types of mechanical composition of sediments on the surface of Central Plateau.

1--muddy sand (St. 1062, 256 m); 2--sandy mud, well sorted (St. 640, 232 m; St. I 2212, 229 m); 3--sandy mud, poorly sorted (St. 1054, 310 m; St. 1489, 246/252 m); 4--sandy mud with a great amount of sand (St. 1126, 294 m); 5--mud having a maximum of fine silt (St. I 2156, 239 m).

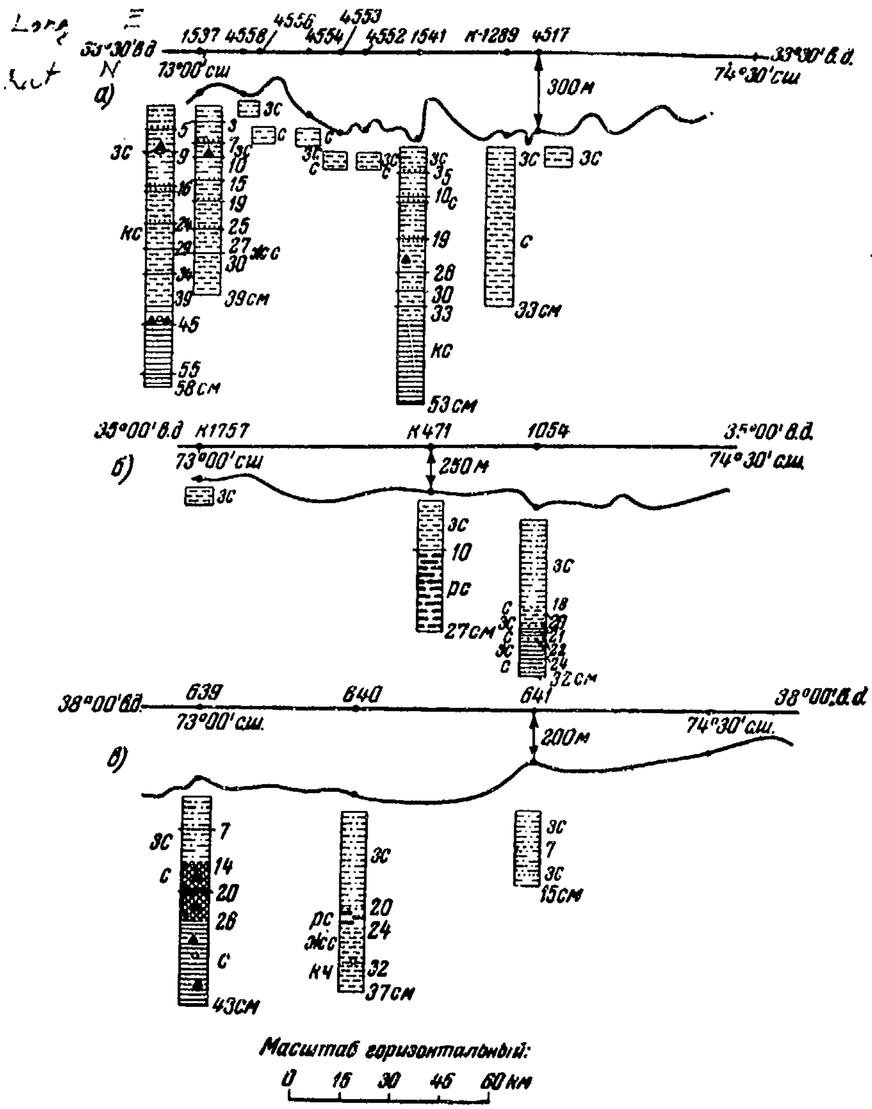


Fig. 56. Bottom Structure of the Central Plateau:

a -- on the cross section along the Kola Meridian (33°30) by cores; б -- along 35°; в -- along 38°. (For explanation of the designating symbols see fig. 46).

Key. Upper line: long. E.........
lat. N.........

Middle line: long. E.........
lat. N.........

Bottom line: long. E.........
lat. N.........

The thickness of contemporary sediments on the Central Plateau fluctuates from 4 to 5 to 23 to 25 cm. The thickness of the upper layer increases a little on the slope of the Central Depression in the cross section along long. 38° E where at the time it was very unstable (Stations 635 through 640). Thus, at one and the same station (at St. 635, 261 m, for instance) the core having penetrated a layer 9 cm thick when lowered for the first time (the length of the core being 20 cm), did not reach the lower layer. When lowered for the second time, though the length of core was 34 cm. However the core brought up the section when lowered again; this time the length of core was 20 cm.

Along the Kola Meridian (St. 1536 and 1537; fig. 56 and 57, 1) the underlying rosy-gray clayey mud is covered with a transitional layer consisting of a mixture of greenish-gray and rosy-gray sediments containing shingles of gray calcareous schist. To the east, in a cross section along longitude 35° E (St. 1060, 269 m), the underlying layer is yellowish-gray, dense, heavy, related to clayey mud (24 to 46 cm of core); it is covered by a transitional layer (11 to 24 cm of core) where an alternation of greenish-gray sandy mud is observed; the latter forms pockets filled with greenish-gray sediments (fig. 56 and fig. 57, 2). In the core was found shingle consisting of rosy-colored granite. To the south, under muddy sand (St. 1062) and under a transitional layer lies a dense, gray and uniform mud. In the northern portion of the area the underlying layer consists of a very viscous, dark-gray, clay-like mud (St. 1054). Lastly on the slope leading to the Central Depression, the lower layer

is represented by a gray, dense, heavy and almost nonsaline sediment which bubbles slightly from acids and contains a great quantity of gravel formed of gray schist, light limestone and weathered igneous rocks. The position of layers is oblique, their interbedding irregular (St. 640; fig. 56 and 57, 3).

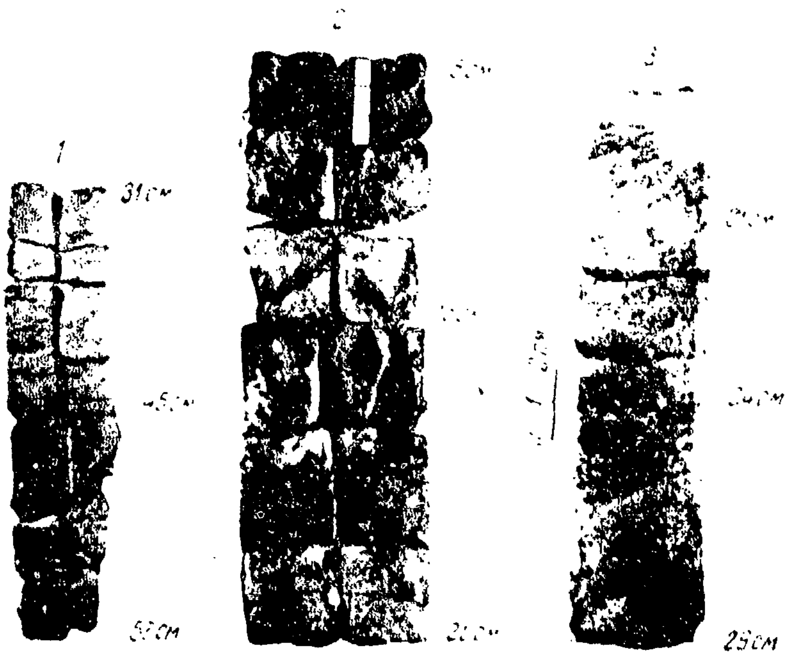


Fig. 57. Cores of Sediments in the Central Plateau

1--the lower layer of core, St. 1537, 231 m, interlayer of gravel at 45 cm; 2--inclusion of greenish-gray sandy mud in gray mud (St. 1060, 269 m; 15 to 23 cm of the sample column); 3--oblique status of layers consisting of rosy-gray mud on the underlying layer (St. 640, 232 m; 17 to 29 cm of the core).

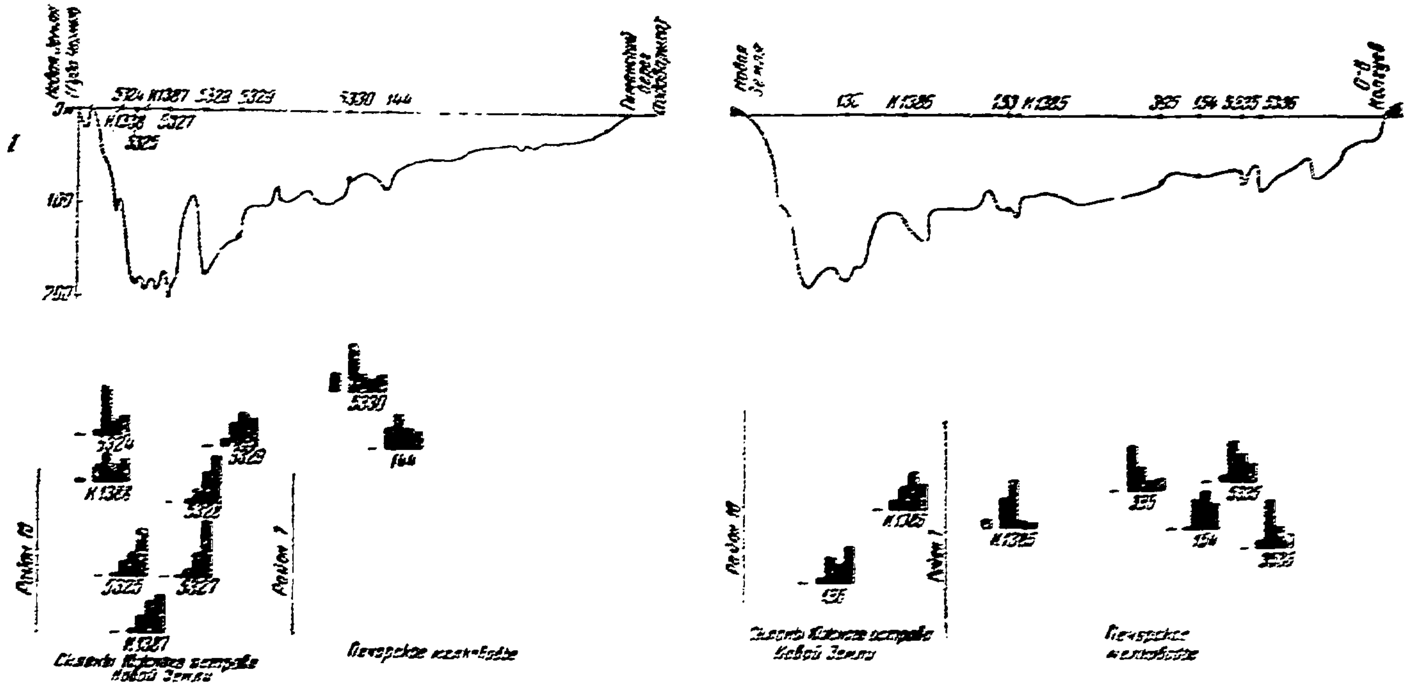


Fig. 58. Changes with depth in the mechanical composition of sediments near Novaya Zemlya.

<u>Key.</u> Upper left-hand corner: Novaya Zemlya (Guba Chernaya)

Upper center: Timanskiy Coast (T. bereg) (Khodovarikha)

Novaya Zemlya

Upper right-hand corner: Kolguyev Island (ostrov Kolguyev)

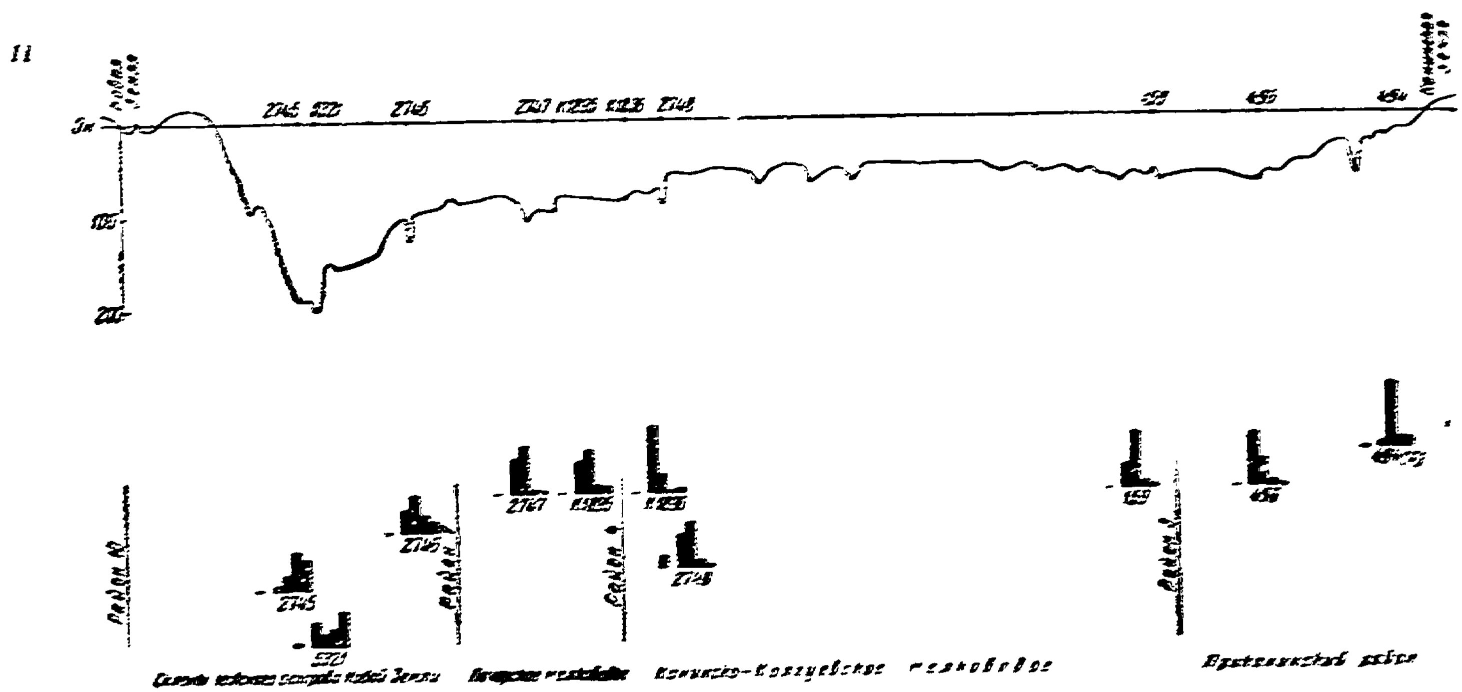
Lower section of the figure - Vertical lines, from left to right:

rayon (area) 10 — 7 — 10 — 7

Horizontal lines from left to right:

Slopes of the south island of Novaya Zemlya — Pechora Shoals — Slopes of the south island of Novaya Zemlya — Pechora Shoals

Fig. 53.



Upper left-hand corner: Novaya Zemlya

Upper right-hand corner: Kaninskaya Zemlya

Lower section of the figure - Vertical lines, from left to right:

rayon (area) 10 — 7 — 4 — 3

Horizontal lines, from left to right:

Slopes of the south island of Novaya Zemlya — Pechora Shoal — Kanin-Kolguyev Shoal — Pre-Kanin Area.

One hypothesizes that here the contemporary marine sediments lie on the surface of a weathered cover of sediments formed on the original rocks. The region must be investigated by more powerful instruments because the original rocks evidently lie at shallow depths and long cores enable us to identify the geological structure and formation of the region.

Because of gentle bottom relief and relatively little active hydrodynamical factors indicating the absence of contemporary erosion and despite the fact that the underlying layer is found at a shallow depth, the graph presenting the mechanical composition of sediments (table 9) contains only slight deflections reflecting individual particles (fig. 43), which shows an almost complete absence of materials derived from other sources.

10. Slopes of the South Island of Novaya Zemlya

The southern area of Novaya Zemlya includes the southern and western submarine slopes of the South Island of Novaya Zemlya to a depth of approximately 200 m on the north, as well as the Trench of Novaya Zemlya. On the south the boundary runs along the submarine shelf separating the Pechora Shoal from the Pre-Novaya Zemlya Trench (Prinovozemel'skiy Zhelob), e.g. along the 100 m isobath. The boundary between the shoaling spur of Goose Land Island (ostrov Gusinaya Zemlya) and the area of Goose Bank (Gusinaya banka) has been arbitrarily drawn in northwesterly direction where it touches the base of the western slope of the south island extending to the Central Depression at a depth of 200 to 250 m.

In the coastal area the bottom relief is very uneven, but most of the bottom samples were taken at a depth greater than 100 m, and only few stations describe the coastal belt.[1] At a depth greater than 100 m the relief becomes rather even but the 200 m isobath again shows individual and relatively short trenches descending toward the Central Depression.

Related to the diversity of bottom relief forms, the sediments are represented by all bottom types, including clayey mud. Within the boundaries of the 50 m isobath, except for entrances to individual gulfs and bays, the bottom is covered by boulders, detritus, less often by shingle, sometimes by shells. At a number of places outcrops of original rocks have been noted, which interfere with the use of fishing equipment. Because of numerous islands, shoals, underwater and abovewater stones, the belts covered by coarse fragments around the south island of Novaya Zemlya have a complex configuration. Here one can identify on the bottom the extension of ridges of original rocks which are exposed on the coast and are characterized by a northwesterly direction. The coastal zone of Novaya Zemlya must become an object of a special research in order to elucidate its morphology, geological structure and origin. To a depth of 100 m the bottom is covered by sand containing a large amount of boulders, shingle and detritus whose numbers increase on traverses of

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[1] Data of the following cruises of survey ship Persei (Persey) were used: the 4th cruise in 1924 by T. I. Gorshkova; 8th in 1925, 14th in 1927, 29th in 1930 by M. V. Klenova; 46th in 1933, by V. M. Ratynskii; 49th in 1934 by P. N. Novikov; 71st in 1938 by P. S. Vinogradova; 80th in 1939 by O. N. Kiselev; of survey ship Knipovich: 48th cruise in 1934 by S. I. Malinin; 52nd in 1935 by N. N. Khokhlin.

capes and on the underwater extension of the Goose Land Island (ostrov Gusinaya Zemlya). At depths exceeding 100 m, sand is replaced by muddy sand which occurs as deep as 150 m on the western slope of Novaya Zemlya and deeper at places, turning into sandy mud on the slopes of the Central Depression. At the southwestern and western coast stretches a belt of sandy mud rich in coarse fragments; on the slope of the Trench of Novaya Zemlya (Novozemel'skiy Zhelob) it merges with sandy mud covering the southern slope of the former. The bottom of the trench is /151 covered by mud and at places by clayey mud. The northern slope of Novaya Zemlya Trench (Novozemel'skiy Zhelob) is very steep (P. S. Vinogradova, 1957). This is, evidently, associated with breaks and faults along which the sagging of bottom of the trench occurred. Because of the steepness of the slope, coarse-grained sediments lie directly adjacent to sandy mud and mud (fig. 58).

The sand of the western slope of the south island is adapted to the steep slope (St. 1622, 118 m; St. 1624, 160/118 m). Its color is greenish-gray, poorly sorted, the sand contains a great amount of particles ranging from 0.25 to 0.10 mm and from 0.10 to 0.05 mm, as well as broken shells, gravel composed of gray sandstone, and shingle of Novaya Zemlya rocks (gray and pink sandstone, diabase, vein quartz, clayey schist). The shingle is mostly fresh, overgrown with barnacles, hydroids and other organisms. In the sand prevail smooth and semi-smooth grains of quartz, the other constituents are feldspar, magnetite, rosy-colored garnet, mica and carbonate fragments, sometimes also semidissolved shells of Astarte sp.

The muddy sand bears the same characteristics; it contains organic remains consisting of many chitin tubes of worms, fragments of ophiuroids, mollusks, sand rhizopods; detritus and shingle are represented by the black limestone and diabase; as in sand, one can find semidissolved shells of Astarte sp., Leda pernula. The muddy sand which is found on the western slope of the Central Depression where it is touched by the Nordkapp Current and between the Goose Bank (Gusinaya banka) and the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) has the highest sorting (St. 2497, 149 m; fig. 59). The sandy mud (St. 368, 130 m for instance) found here bears the same character, but at great depths its upper layer has sometimes a pink color, whereas the quantity of organic substances is small. The sediment is incoherent, weakly cemented, has many cracks and pores.

At greater depths at the base of slope where the Central Depression begins (St. 1619, 217 m; St. 1626, 230 m) the sandy mud has a brilliant greenish-gray color with a light yellowish hue, it is strongly cemented, which leads to a change in the mechanical composition graph (fig. 59, a maximum of fine silt). In the sandy mud on the western slope one can find shingle consisting predominantly of gray sandstone. The sandy mud lying to the southwest of Kostin Shar (St. 133, 165 m) in an isolated pit near Mezhdusharskiy Island (ostrov Mezhdusharskiy) (St. 2745, 190 m) and on the southern slope of the Novaya Zemlya Trench (Novozemel'skiy Zhelob) is also poorly sorted. The sandy mud lying on the northern slope of the Novaya Zemlya Trench (Novozemel'skiy Zhelob), in isolated pits and

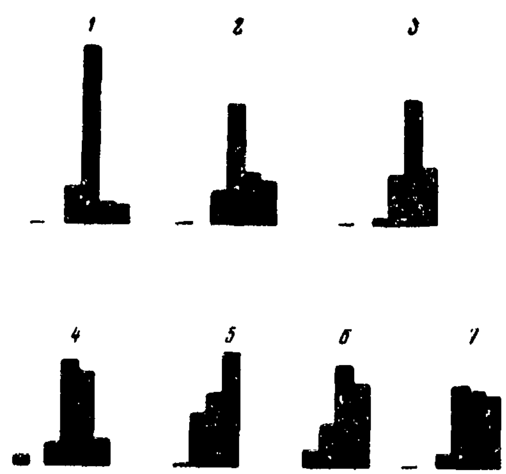

Fig. 59. Types of mechanical composition of sediments on the slopes of the South Island of Novaya Zemlya:

1 -- muddy sand (St. 2497, 149 m); 2 -- sandy mud (St. 368, 130 m); 3 -- sandy mud with a maximum of fine silt (St. 1619, 271/277 m); 4 -- poorly sorted sandy mud (St. 133, 165 m); 5 -- mud (St. 372, 185 m); 6 -- mud with a maximum of fine silt (St. 2745, 190 m); 7 -- mud represented by a graph having equal apices (St. 149, 120 m). (For explanation of symbols see fig. 33).

bays of the south island of Novaya Zemlya is characterized by poor sorting having a maximum of coarse silt. Among the organic remains one can most frequently find chitin tubes of worms encased with ocherous /152 rims; among coarse-grained material: detritus of gray schist, limestone, rosy-colored granite (St. 831, 23 m, for instance). The mud samples obtained from the Novaya Zemlya Trench (Novozemel'skiy Zhelob) (St. 149, 120 m, etc.) are also characterized by poor sorting, the graph presenting their mechanical composition has equal apices. At great depths, a more fine-grained material is deposited whose graphical presentation of mechanical composition has one apex and which has a maximum of particles smaller than 0.01 mm (St. 372, 185 m, etc; fig. 59). The same character marks the clayey mud (St. 5327, 200 m).

The slopes of the Novaya Zemlya Trench (Novozemel'skiy Zhelob) team with benthos (biomass is as large as 400 g/m^3, according to V. A. Brotskaya and L. A. Zenkevich, 1939). A luxurious development of plankton and benthos in the region of the "Polar Front" furthers the formation of a great quantity of organic detritus which is accumulating in protected areas together with minute particles of mineral substances. The rich organic material creates an aggregate structure of sediments leading to a greater-than-usual cementation in dry condition and to a maximum of fine silt in graphs of the mechanical composition. Certain roles in the cementation of bottom by organic matter can be attributed to the mollusks Portlandia arctica. They belong to the mud eaters, filtering through their intestines considerable masses of bottom material and producing a large population at great depths in the Novaya Zemlya Trench (Novozemel'skiy Zhelob).

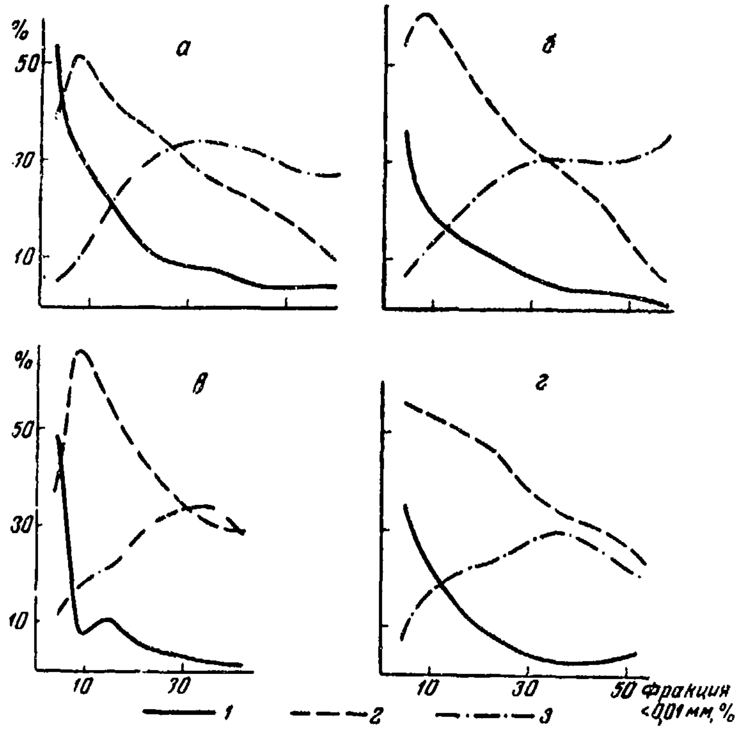

Fig. 60. The mean mechanical composition of sediments in the central part of the Barents Sea - in areas characterized by a complex relief:

a -- 10th area — slopes of the south island of Novaya Zemlya; б -- 11th area — the northern Novozemel'skoye Shoal; в -- 12th area — the Central Elevation; г -- 13th area — Persey Elevation; fragments: 1 -- 1.0 to 0.1 mm; 2 -- 0.1 to 0.05 mm; 3 -- 0.05 to 0.01 mm.

The cores up to 88 cm[1] long have nowhere included the material of layers lying below the contemporary layer because the Novozemel'skiy Trench and all the protected areas are characterized by an intensive accumulation of materials washed off the Pechora Shoals and the slopes of the south island of Novaya Zemlya. The variation in mechanical composition corresponds here to the variation in depth. A graph of the mean mechanical composition (table 10) reflects the admixture of coarse-grained material on shoals and steep slopes which results in a sharp decline of sand particles and in an increase of coarse silt in the muddy sand range (fig. 60, a to з).

Besides the considerable thickness of deposits and their poor sorting, the process of accumulation in the Novaya Zemlya Trench (Novozemel'skiy Zhelob) is marked by the character of chlorophyll distribution (V. P. Zenkovich and L. A. Iastrebova, 1946); the quantity of the matter decreases regularly with depth, reflecting its gradual decomposition.

11. The Northern Shoal of Novaya Zemlya
(Novozemel'skoe melkovod'ye)

The Northern Shoal of Novaya Zemlya (Novozemel'skoye melkovod'ye), limited by the 250-m isobath, is separated from Novaya Zemlya Island (ostrov N.Z.) by a deep depression — the Northern Trench of Novaya Zemlya (Novozemel'skiy Zhelob) which extends in the NNE direction along the central section of

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[1] At Station 371 (181 m) in Novozemel'skiy Trench a regular bottom corer 1 m long lifted a sample 88 cm long on September 8, 1925, which was the longest sample obtained at the time (M. V. Klenova).

Table 10

THE MEAN MECHANICAL COMPOSITION OF SEDIMENTS NEAR NOVAYA ZEMLYA

Bottom Type	Fragments < 0.01 mm in %	Depth in m		Fragments in mm					Number of Analyses
		from-to	mean	> 1	1-0.1	0.1--0.05	0.05--0.01	< 0.01	
Slopes of the South Island of Novaya Zemlya									
Sand	< 5	55-160	107	(3,4)	53,8	39,1	4,1	3,0	10
Muddy Sand	5-10	95-165	124	(2,3)	33,0	51,2	8,9	6,9	15
Sandy Mud	10-20	18-266	153	(2,8)	22,2	42,7	21,4	13,7	19
" "	20-30	23-277	156	(2,2)	9,3	34,4	32,0	24,3	13
Mud	30-40	113-200	158	(1,0)	7,6	25,3	32,7	34,4	6
"	40-50	130-190	172	(0,2)	3,6	21,0	30,6	44,8	6
Clayey Mud	> 50	185-200	192	(0,4)	3,7	13,4	27,0	55,9	2
The Northern Shoal of Novaya Zemlya (Novozemel'skoye melkovod'ye)									
Sand	< 5	33-291	156	(3,6)	36,4	53,7	6,1	3,8	10
Muddy Sand	5-10	68-280	162	(3,3)	20,9	61,6	9,9	7,6	31
Sandy Mud	10-20	50-260	164	(3,8)	14,9	52,3	18,6	14,2	34
" "	20-30	60-364	184	(5,5)	8,9	39,2	27,9	24,0	21
Mud	30-40	103-250	186	(3,8)	4,9	28,0	30,7	36,4	11
"	40-50	100-285	197	(6,0)	4,4	20,4	30,1	45,1	12
Clayey Mud	50-60	60-97	82	Traces	0,8	5,9	34,7	58,6	3

Novaya Zemlya. The trench separates from the island the Novozemel'skaya banka — an elevation 150 m deep stretched in the same direction. The slopes of the trench and the shoal are intersected by numerous valleys, the bottom relief being very complex. The origin of the trench is tectonic but it is possible that later, according to P. S. Vinogradova (1957), it was eroded by a glacier. Very sharp changes in the relief /154 are observed at the bend of the trench toward the west — the Central Depression. To the north of Novaya Zemlya Shoal (Novozemel'skaya banka) a number of trenches and elevations are observed, the widest of which is called the Shoal Water of Gorbovy Islands (ostrova Gorbovy). To the north the Novaya Zemlya Trench (Novozemel'skiy Zhelob) almost reaches a deep branch of the Polar Basin Bay (Bukhta Polyarnogo basseina). Near the northern end of Novaya Zemlya there is one more shoal ridge with a rough but little investigated relief. At Cape Zhelaniya (Mys Zhelaniya) the shoal water becomes very narrow and depths exceeding 400 m occur at a distance of 10 km from the coast for instance.

The western boundary of the area runs along the slopes of the Central and Northeastern depressions, but from the Northern Plateau the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) is separated by isolated individual elevations, as well as one can conclude from insufficient soundings. In connection with the complex relief, the sediments of the area are characterized by a great variety and diversity of distribution. Outcrops of old clay have been observed on steep slopes. Core samples consisting of two layers have been obtained at a number of stations.

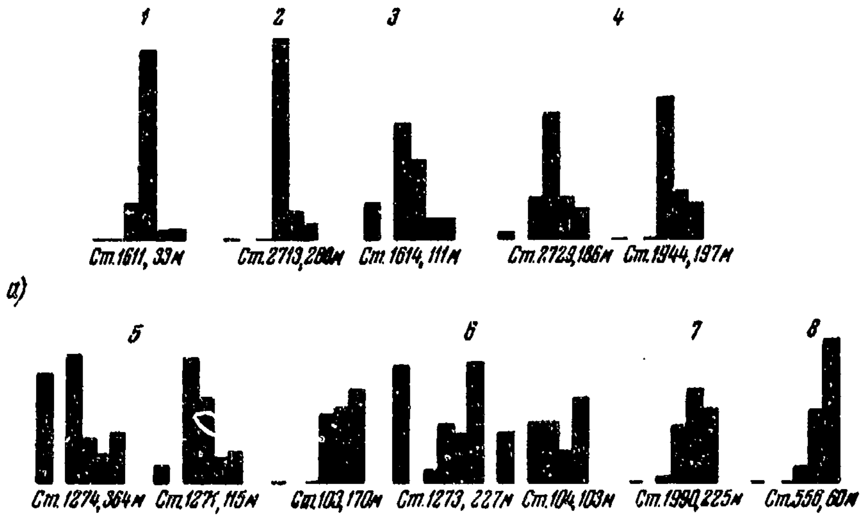

Fig. 61a. Mechanical composition of sediments on the Northern Novaya Zemlya Shoal(Novozemel'skoye Melkovod'ye):

1--sand (St. 1611, 33m); 2--muddy sand (St. 2713, 280 m); 3--muddy sand with a great quantity of sand particles (St. 1614, 111/109 m); 4--sandy mud on a level surface of elevation (St. 2729, 88 m; St. 1944, 197 m); 5--sandy mud on a slope (St. 1274, 364 m; St. 1271, 115 m); 6--mud (St. 103, 170 m; St. 1273, 227 m; 104, 103 m); 7--mud with a maximum of fine silt (St. 1990, 225 m); 8--clayey mud (St. 556, 60 m).

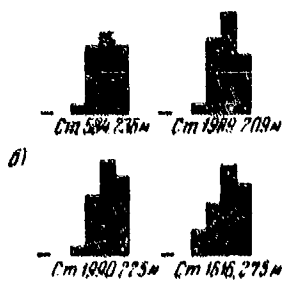

Fig. 61b.

In the Northern Trench of Novaya Zemlya (Novozemel'skiy Trench) (St. 584, 236 m; St. 1989, 209 m; St. 1990, 225 m; St. 1616, 275 m). (For explanation of symbols see fig. 33).

As usual, the coarsest material is found along the coast, especially on the extension of projecting capes.[1] Because of the broken relief of the underwater slope one can find sand on the steep slopes of underwater elevations and at considerable depths along the edges of shoal waters, as well as in coastal areas; i.e. sand extends far from the coast. The coastal sand is gray, its mechanical composition fine (dust-sand. St. /155 1611, 33 m; fig. 61), consisting predominantly of quartz with an admixture of broken shells of Cardium. On the slopes of elevations of Gorbovy Islands (ostrova Gorbovy; St. 102, 150 m, etc.), as well as at the base of the slope extending to the Central Depression (St. 1984, 291 m), on the extreme southwestern projection of shoal water, on a steep slope (St. 766, 136 m; 1993, 184 m; 1994, 215 m; fig. 62) the color of sand is greenish-gray; it contains a considerable (up to 30%) percentage of particles ranging from 1 to 0.1 mm, calcareous rhizopods and other carbonate remains, a noticeable admixture of mica and a large quantity of gravel, shingle and detritus - weathered pinkish-gray limestone, gray schist, sandstone, especially on the extreme northern extension (St. 1270, 82 m).

On the eastern submarine slope of Novozemel'skiy Trench, the muddy sand lies in a relatively narrow belt, widening in the area of the proliv

[1] The data obtained during the following cruises of the survey ship Persei (Persey) have been used: the 3rd in 1923, 13th in 1927, 21st in 1929, 36th in 1931 by T. I. Gorshkova; 11th in 1926, 29th in 1930 by M. V. Klenova; 49th in 1934 by P. N. Novikov; 71st in 1938 by P. S. Vinogradova.

Matochkin Shar (Strait of M. Sh.) where it gradually merges with the sandy mud which borders on a muddy sand. It also covers the surface of shoals; along the northern slope of the western extension of the Novaya Zemlya Shoal (Novozemel'skaya banka) it descends to a depth exceeding 250 m but along the southern slope it stretches almost to the Strait of Matochkin Shar (proliv Matochkin Shar). Here, in contrast to other areas where the graph of mechanical composition shows a maximum of coarse silt, the muddy sand contains a considerable quantity of sand ranging from 1 to 0.1 mm (St. 1614, 109 m, on the slope of underwater extension of Mys Sukhoi Nos - Cape S. N.; St. 1992, 195 m on the underwater slope of the Novaya Zemlya Shoal (Novozemel'skaya banka)). This indicates that the outcrops of original rocks yielding the coarse-grained material are not far from here. The samples contain a considerable admixture of gravel and small shingle consisting of gray schist and sandstone. The color of the muddy sand is greenish-gray, except for the northern slope of the Novaya Zemlya Bank (Novozemel'skaya banka; St. 565, 248 m) where the color is pink and the weathered shingle of the gray stratified limestone and the gray schist are covered by a film of brown oxides. The shells Pecten groenlandicus represents here the organic remains.

Most of the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) is covered with sandy mud which is represented by several types (fig. 61, 4). Well sorted sediments whose mechanical composition is characterized by a graph with one apex are found in the majority of cases on a comparatively even surface in the northern part of the area (St. 2729, 186 m; St. 558, 185 m,

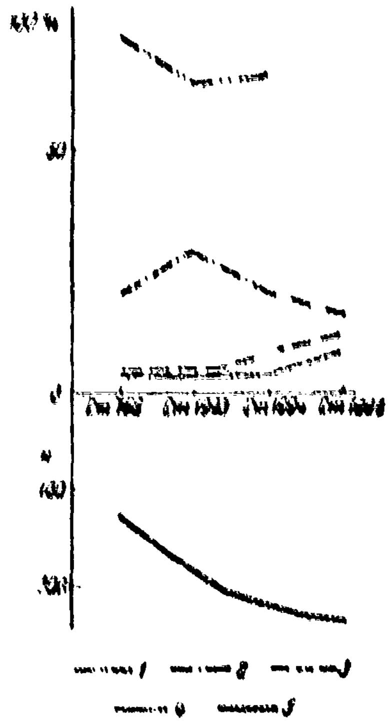

Fig. 62. Changes in the mechanical composition on the slope of the Northern Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) extending to the Central Depression (Stations 766, 1993, 1994, 1996):

1--particles from 0.1 to 0.05 mm;

2--particles from 1 to 0.1 mm;

3--particles from 0.05 to 0.01 mm;

4--smaller than 0.01 mm;

5--the depth.

etc.). The sandy mud here is bright, yellowish-gray or pinkish-gray; the sandy mud contains a considerable admixture of sand particles and coarse fragments - gravel and shingle of quartz and gray schist and a slightly weathered pink sandstone and ocherous particles, notably around the chitinous tubes of worms. The same type of well sorted sandy mud, whose mechanical composition is sometimes represented by two apices lies on the slopes of shoal water (St. 1944, 197 m; St. 559, 181 m) on the /156
shoal of Gorbovy Islands (ostrova Gorbovy; St. 562, 76 m), and on the Novaya Zemlya Bank (Novozemel'skaya banka where it borders on a muddy sand. Sorting of the sediments is poorer on the steep slope of Cape Zhelaniya (Mys Zhelaniya; St. 1274, 364 m) and farther to the west on the northern slope of the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) (St. 1271, 115 m).

At Station 1274 near Cape Zhelaniya (Mys Zhelaniya) the depth changed during the survey and a core (20 cm long) was obtained. It represented a typical accumulation of fluvial-glacial deposits (fig. 63) consisting of detritus and shingle of yellowish quartiferous sandstone, black schist and light-gray limestone that was derived from the cape. The quantity of sandy mud increases with depth (in the core). The numerous carbonate remains are represented by calcareous rhizopods and by limy plates of sea lilies.

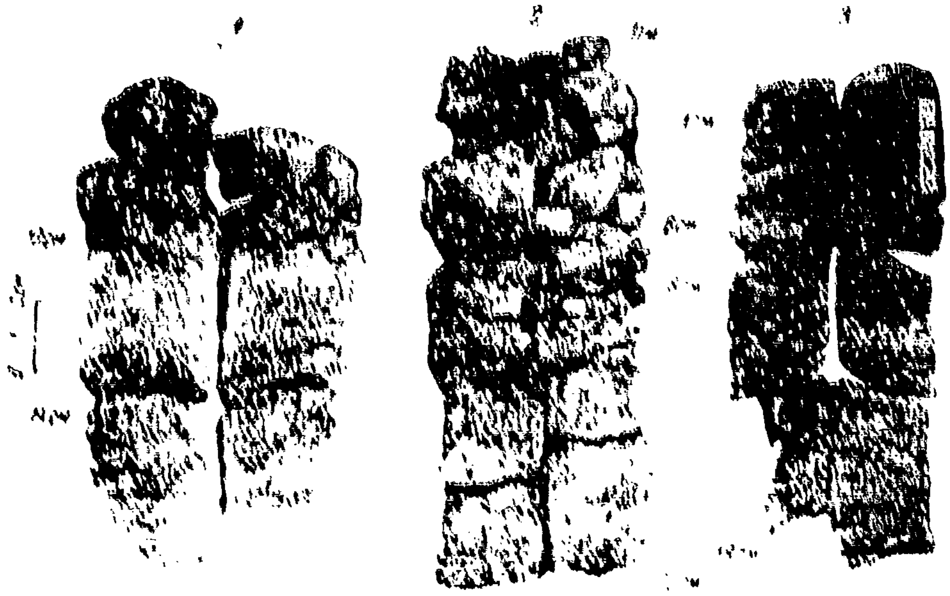

Fig. 63. Cores on the slopes of the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye):

1 -- the lower layer of the core (St. 1996, 230 m). The sandy gray clay with interlayers of greenish-gray sand with gravel at a depth of 10 and 14 cm (of the core);

2 -- the weathered fluvial-glacial deposits near Mys Zhelaniya (St. 1274, 364 m). The length of the core 20 cm;

3 -- the layer of greenish-gray sandy mud covering a more fine-grained gray sediment (St. 2725, 157 m). The length of the core 19 cm; a transitional layer at a depth of 6 to 8 cm (of the core).

In the pits of the northern portion of the area, sometimes at smaller depths than in the case of sandy mud (St. 103, 170 m; St. 1957, 105 m), was found mud whose graph of mechanical composition is marked by one apex and which has a maximum of particles smaller than 0.01 mm. Its color is light-gray with a shade of yellowish hue; it contains numerous calcareous rhizopods and ocherous fragments as well as large quantities of gravel and shingle formed of the dark-gray dolomite, a slightly "burnt" sandstone and weathered siderite. The material is reminiscent of sediments in fjords. This can be readily explained by the fact that the material is found at the extreme southern tip of the trench entering the Polar Basin Bay (Bukhta Polyarnogo basseina). The mud found in the upper reaches of the Novaya Zemlya Trench (Novozemel'skiy Zhelob) (St. 1986, 222 m) and on the slope of the Polar Basin Bay (Bukhta Polyarnogo basseina; St. 1272, 215 m; St. 1273, 227 m) has the same mechanical composition.

In the Novaya Zemlya Trench (Novozemel'skiy Zhelob), the color of mud and the sandy mud is pinkish-gray. The material contains a small amount of shingle and gravel and the graph of its mechanical composition shows a maximum of fine silt (fig. 61). This attests to a cementation of the sediments which is associated with concentration of organic substances /157

in this area of profuse life.[1]

Near the coast (St. 556, 60 m; St. 557, 97 m; St. 2732, 88 m) in the area of Gorbovy Islands (ostrova Gorbovy or Gorbovyye ostrova) a clayey mud devoid of organic remains is deposited. Its color is light-gray, composition uniform, in dry condition the material becomes pulverized and effervesces when tested with acids. Its carbonation is associated with glacial grind of carbonate rocks. Identical sediments are found in sea arms near active glaciers. In open bays and at entrances to sea arms the sediments represent poorly sorted sandy mud or mud replete with fragments of rocks composing the nearby coast (M. V. Klenova, 1931). In contrast to glacial deposits, the sediments contain shells of mollusks *Mya truncata*, *Astarte* sp. and fragments of barnacles.

The thickness of contemporary sediments covering the Northern Shoal of Novaya Zemlya (Novozemel'skoye melkovod'ye) is very variable. Adjacent to areas of exposed slopes, where the original rocks and Quaternary clay are devoid of the cover of contemporary sediments or are covered by them

[1] The peculiar features of mechanical composition of sediments (considerable cementation; the graphical presentation of mechanical composition presenting a maximum of fine silt in the Novaya Zemlya Trench (Novozemel'skiy Zhelob); poorly sorted sand at great depths on the steep slope leading to the Northeastern Depression; the graphical presentation of sandy mud and mud found in areas with a complex bottom relief having two apices, etc), which were established on the basis of collections during the Persei (Persey) cruises from 1923 to 1934, were also found when examining the results of samples collected in 1938 and 1940 as well as in 1946 and 1951 (aboard survey ship Saratov and SRT-400). Thus all of the mentioned peculiarities are not casual but they reflect stable regularities of sedimentation in the given area.

with layer 3 to 25 cm thick, there are areas of accumulation (the Novaya Zemlya Trench - Novozemel'skiy Zhelob, for instance) in which the core samples as long as 60 cm have not included the underlying layer. At the bottom of the samples there appears fine-grained sediments containing a smaller quantity of coarse-grained material, but its general character (color of composition) does not change.

A thickness not exceeding 10 cm is observed on the southern slope of the Novaya Zemlya Bank (Novozemel'skaya banka), on the shoal of the Gorbovy Islands (ostrova Gorbovy or Gorbovyye ostrova) and on the slopes of the Polar Basin Bay (Bukhta Polyarnogo basseina). A thin underlaying layer, which consists usually of fine-grained deposits and differs from the upper layer in color and composition, causes the appearance of two apices in the graph of mechanical composition. The upper layer, consisting of greenish-gray muddy sand or sandy mud, forms a protective cover against erosion, which explains the accumulation of coarse-grained material in it. Sometimes at the interface of two layers one observes a layer of erosion in the form of a ferric ocherous interlayer which frequently contains polished gravel or sand (St. 766, 136 m, at the extreme west end; St. 1996, 330 m, at the same place; fig. 63, 1). At the latter point is found a layer of greenish-gray muddy sand 6 cm thick lying on a rough surface of the gray, dense and heavy rock (type of sandy clay) containing traces of weathering and consisting of interlayers of greenish-gray sand with gravel (fig. 63, 2).

In the northern portion of the area on a shoal overlain with sandy mud of a yellowish-gray or pink-gray color one can find more clay-like sediments: at Station 2729, 186 m, for instance, cores were obtained in which 8 to 14 cm under the shingle of weathered sandstone a sediment was discovered with clay-like lumps of light, yellowish-gray color which bubbled slightly when treated with acid; the material was evidently an accumulation of weathered rocks, possibly, of ground moraine. On the slopes of the northern portion of the shoal water the thickness of the contemporary greenish-gray sediment with irregular texture and a great amount of shingle and gravel is also variable. At St. 2723 a dense rosy-gray mud with carbonate remains was found at a depth of 35 to 43 cm in the cores and it is again underlain by a greenish-gray mud; at St. 2725 the thickness of the upper layer is 9 cm (fig. 63, 3); at St. 2724 the underlaying layer is in the form of a lump on one side of the column. /158
Thus, here the thin upper layer covers a rough surface of the weathered original rocks. On the northern slope of Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) water one can observe irregular stratification of rosy-gray mud and greenish-gray sandy mud (St. 1271; fig. 61) at a depth of 7 to 13 cm of the core beneath which lies a sediment analogous to the upper layer. Such stratification observed in the southern portion of the shoaling water makes one assume the presence of underwater land slides.

In correspondence with the character of sediments on the Novozemel'skoye Shoal, the graph of the mean mechanical composition (table 10) presents a uniform curve of sand particles and bends in the sections of other sediments, which is associated with the influx of additional clay and silt material (fig. 60). As in other areas with a complex relief, a direct connection with depth is absent, i.e. the variation of depth by itself, without accounting for the configuration of underwater depressions and elevations, is not reflected in the composition of sediments.

12. The Central Elevation

In contrast to the areas discussed before, which directly adjoin the coast, the Central Elevation of the Barents Sea having a depth of 150 m between the Central Depression and the Western Trench is included in the system of north-south elevations which divide the western and eastern portions of the sea and do not adjoin the coast. The boundaries of the Central Elevation have been conditionally drawn along the 250-m isobath. To the north it is separated from the Persey Elevation by a shallow depression 250 m deep, to the south by the Central Plateau.

In accordance with a bathymetric chart (fig. 14), the Central Elevation consists of two parts located in echelon shape and divided by considerable depressions. The slopes of the elevation are intersected by trenches descending from it to all the sides. The most probable direction of the original rocks lying on the Central Elevation is the northeasterly direction; however, the number of depth measurements is not yet sufficient

to form a complete pattern of bottom relief, and with the accession of more thorough information, the elevation will disclose more complex contours.

The sediments of the area are represented mainly by muddy sand and sandy mud.[1] Sand is found only on certain shallow projections, but mud and sandy mud verging on mud accumulate in depressions, predominantly on the southern slope. The Central Elevation is the center where a great quantity of coarse fragments accumulate - namely, boulders, shingle and detritus of a peculiar lithologic composition (M. V. Klenova, 1937). In connection with the peculiarities of hydrological regime, the material is subject to intensive underwater weathering (it. 1936).

The sand covering one of the peaks of the western ridge of the Central Elevation (St. 1510, 164 m) and the muddy sand covering the higher areas of the western spur and the surface and slopes of the eastern spur (St. 181, 190 m; St. 2469, 180 m, etc) have greenish-gray color and are well sorted, whereby the quantity of sand (1 to 0.1 mm) and silt (less than 0.01 mm) particles correspond to the bottom relief: the former decreases regularly with depth but the latter increases (fig. 64). On the eastern

[1]The data obtained during the following cruises of the survey ship Persei (Persey) have been used: the 3rd in 1923, 5th in 1924, 12th and 13th in 1926, 17th in 1928, 21st in 1929, 50th in 1934 by T. I. Gorshkova; 19th in 1929 by K. R. Olevinskii; 27th in 1930 by A. S. Ruchik; 28th in 1930, by V. P. Zenkovich; 46th in 1933 by V. M. Ratynskii; 49th in 1934 by P. N. Novikov; 70th in 1938 by O. N. Kiselev; the 24th cruises of the survey ship Knipovich in 1931 by K. A. Rachkovskaia, and the 26th cruise of the survey ship Issledovatel' in 1940 by P. S. Vinogradova.

slope the muddy sand contains a great quantity of quartz, feldspar, garnet, few calcareous remains, calcareous rhizopods, many tubes of worms /159 and single polished coarse grains of quartz. As the depth increases, the muddy sand merges with a well assorted sandy mud of the same type, sometimes with an admixture of sandy rhizopods. The color of the sandy mud is yellowish-gray, but in the northern part of the elevation it is pinkish-gray when fresh. In areas where the underlying layer does lie deeply, i.e. where erosion is active, the sandy mud is characterized by considerably poorer sorting; it contains a great admixture of gravel and shingle, and the graph of its mechanical composition has two apices (St. 88, 250 m, on the eastern slope; St. 1048, 172 m, on the surface of the western portion; St. 1163, 204 m, on the eastern slope of the southwestern spur and a number of others). The sandy mud characterized by smaller particles has a greenish-gray color, sometimes with a slight yellowish hue; it is deposited side by side with a mud having a similar composition on the bottom of an underwater gulf which opens widely toward the south; the bottom of the gulf gently slopes from a depth of 200 m toward the great clay masses of the Western Trench (Zapadnyy Zhelob). The mechanical composition of the sediment is here very stable because the samples obtained at a considerable distance from one another have an almost identical mechanical composition: their graphs usually approach the type characterized by equal apices, sometimes there is a maximum of particles smaller than 0.01 mm (fig. 65 and 66). Changes in the mechanical composition reflect in the profiles.

In connection with a profuse development of plankton in the region of "the polar front" (L. A. Zenkevich, 1947) the sediments of the Central Elevation area contain a large quantity (up to 2.8 mg/100 g) of chlorophyll. Variations in the amount of chlorophyll by cores (V. P. Zenkovich and L. A. Iastrebova, 1946) point out an intensive accumulation. Local bottom elevations that are subject to erosion serve as sources of the material for sediments accumulating at a great distance from land.

The Central Elevation is a center for the propagation of great quantities of coarse fragments restricted only to a given area.

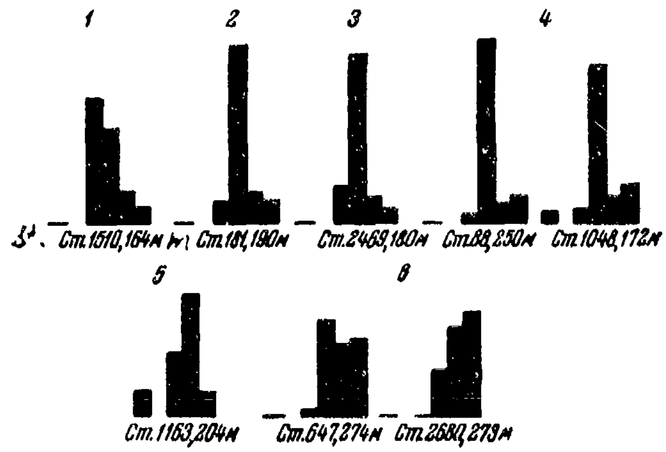

Fig. 64. Types of mechanical composition of the sediments covering the Central Elevation:

1--sand (St. 1510, 164 m); 2--muddy sand (St. 181, 190 m); 3--muddy sand with great quantities of sand particles (St. 2469, 180 m); 4--sandy mud (St. 88, 250 m; St. 1048, 172 m); 5--weakly assorted sandy mud (St. 1163, 204 m); 6--mud (St. 647, 274 m; St. 2680, 273 m). (For explanation of symbols see fig. 33).

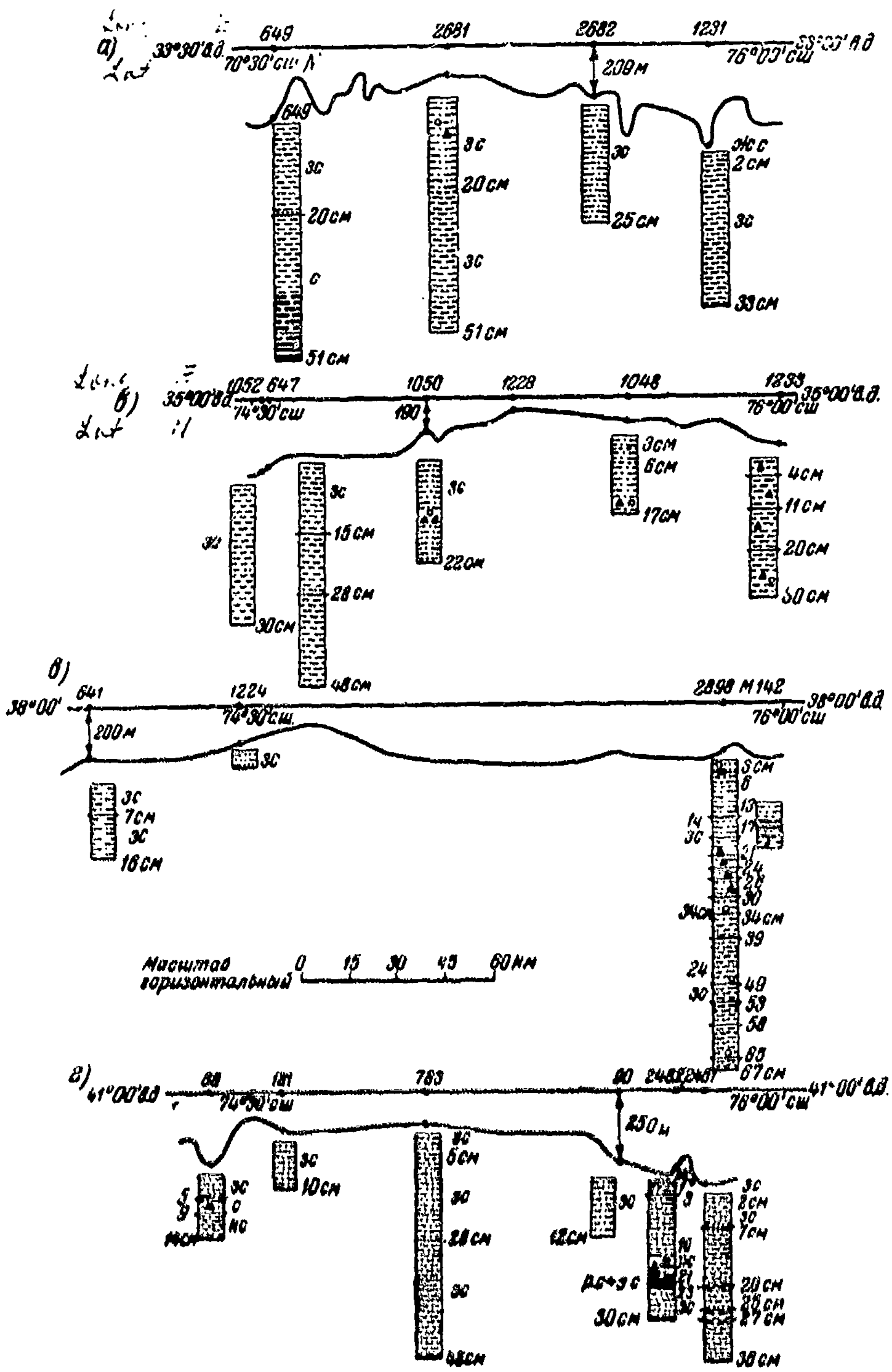

Fig. 65. The structure by profiles of the Central Elevation of the Barents Sea: a—along the meridian of 33°30' across the southwestern spur of the elevation; б—along the meridian of 35° across the northwestern portion of the elevation; в—along the meridian of 38° across its narrowest part; г—along the meridian of 41° on the eastern slope of the elevation. (Explanation of symbols in fig. 46).

The samples obtained by bottom grabs and even the lower layers of cores contain shingle, detritus and gravel of the gray clayey and carbonaceous schist, light-gray and rosy-colored granite and various sandstones, such as the fresh light-gray type, the stratified type permeated with brown oxides, the soft gray type, the quartzitic conglomerate, the basalt wrapped in a coating of brown oxides, the gray stratified limestone, siderite, marl, coal, etc. The presence of shingle frequently obstructs the taking of given samples because many of them end at reaching the shingle or in the layer consisting of gravel.

Despite their small length, most of the cores taken from the Central Elevation disclosed the underlying layers. The thickness of the upper layer fluctuates from 6 to 30 cm. At a depth of 16 cm of a core taken from the southwestern spur of the western portion of the elevation (St. 650, 175 m) one can find gray muddy sand lying under a greenish-gray sandy mud; at a depth of 18 cm it is replaced by gray mud (with a light rosy-colored hue) which is well cemented and heavy; at the bottom of the core the mud contains shingles of gray granite, but the upper part of the core contains much gravel formed of fragments of rocks. The quantity of gravel decreases toward the bottom of the core (length 30 cm). On the eastern slope of the same southwestern spur (St. 1163, 204 m), the gray mud with gravel and a small amount of sand, smooth shingles of sandstone and gray granite is covered by a sandy mud 8 cm thick without any transitional layer. Farther from the slope, in the western part of the underwater gulf (St. 649, 235 m), as well as in its southern part (St. 648, 263 m) the

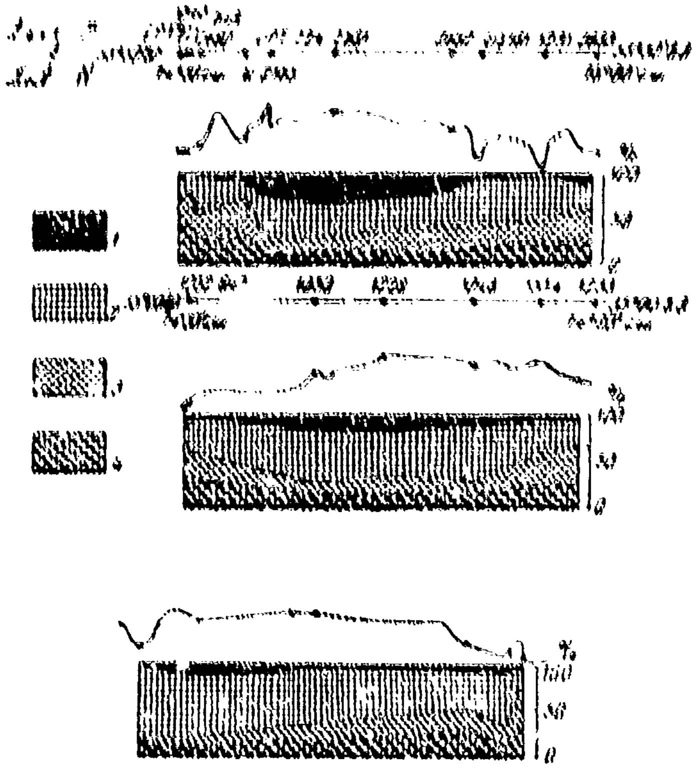

Fig. 66. Variations with depth in the mechanical composition of the surface layer of sediments on the Central Elevation by profiles a, б, в (see the preceding figure). Explanation of symbols (1 to 4) in fig. 32.

lower section of core, which gradually merges with the upper greenish- /162
gray sediment, has a gray color with a light rosy-colored hue; it consists of gravel, formed of quartz and of carbonaceous schist wrapped in brown oxides, and of shingle formed of gray granite and representing, evidently, a redeposited material of rocks lying higher up the slope under the contemporary sediments. The cores taken from the central part of the underwater gulf at places where accumulation occurs, were 48 cm long containing only contemporary sediments, but at St. 245 (259 m) the core was 43 cm long, ending in the rosy-gray clayey mud which was very dense and little

saline, whereas the greenish-gray mud covering the former was very saline and contained remains of plants (Fig. 67).

Fig. 67. Cores of the Central Elevation.

1-- a sudden replacement of the gray sandy mud (old) with gravel and shingle formed of sandstone and gray granite by a greenish-gray (contemporary) sandy mud at a depth of 8 cm in the core (St. 1163, 204 m); 2--plant remains found in the lower section of a core in a greenish-gray sediment overlying a pinkish-gray layer: a--the view of a lengthwise cross section of core; б--the view of a transverse cross section of core (St. 645, 269 m); 3--ochorous interlayer on a rough surface of the lower layer at a depth of 12 cm of the core (St. 2899, 176 m; at a depth of 7 to 24 cm of the core).

On the western slope of the southern spur (St. 643, 222 m) a muddy sand 12 cm thick lies on the layer of a gray sandy clay which is dense and heavy, containing, as in the case of the southwestern spur, gravel of gray schist and gray granite.

In the depression of the northern slope of the Central Elevation, the underlying layer is not exposed. In its central part along the long. 38° E, where the thickness of the contemporary layer is only 6 cm, one can find an ocherous interlayer on a rough surface of the underlying layer at a depth of 12 to 13 cm (St. 2899, 176 m; fig. 67, 3). The lower layer is represented by a dense, heavy and non-saline pinkish-gray mud (which effervesces when treated with acid) with a great quantity of gravel and shingle of a soft gray sandstone. Above the ocherous interlayer at a depth of 7 to 11 cm of the core, one can observe a blend of the upper and lower layers. A similar transitional layer is observed at a depth of 18 to 22 cm of a core taken from the eastern slope (St. 762, 196 m) where one can find gravel formed of a porous weathered sandstone (fig. 68). On the northeastern spur of the elevation (St. 2464, 209 m; St. 2462, 265 m) and on its eastern slope (St. 2465, 210 m) one can observe an interlayer consisting of pinkish-gray mud which is slightly carbonated and contains a great amount of gravel; this interlayer lies beneath the upper layer consisting of well sorted sandy mud 15 and 13 cm thick. The upper and lower surfaces of the interlayers found at depths of 16 to 21 cm and 14 to 17 cm of the core are uneven; lower in the core the interlayers are replaced by irregular interstratification of greenish-gray

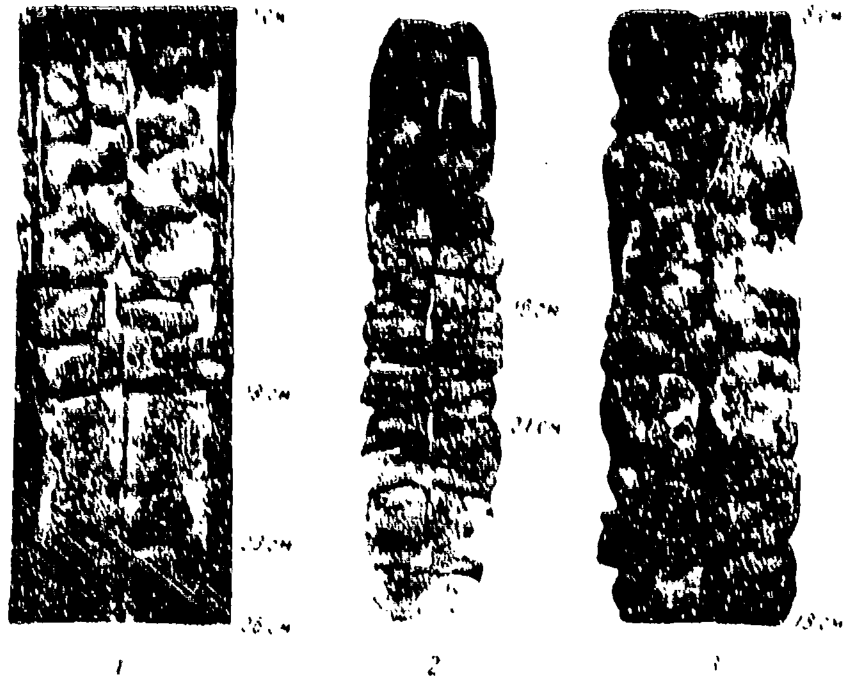

Fig. 68. Stratification of Sediments in the Central Elevation.

1 -- St. 762, 196 m (from 1 to 26 cm of core). At a depth of 18 cm the greenish-gray muddy sand is replaced by a transitional layer consisting of a mixture of greenish-gray and pinkish-gray sediment, and at a depth of 23 cm it is replaced by a pinkish-gray sandy mud; 2 -- St. 2642, 265 m. At a depth of 16 to 21 cm of the core one can see an interlayer of pinkish-gray stratified mud; 3 -- St. 2465, 210 m. Interstratification of greenish-gray and pinkish-gray sediments at a depth of 6 to 18 cm of the core (may be the traces of sliding).

and pinkish-gray sediment (fig. 60), which is evidently associated with underwater landslides. The same interstratification is also observed outside the bounds of the Central Elevation (St. 2473, 281 m); however, on an isolated elevation (St. 2469 and 2470) at the base of the slope 180 to 248 m deep the cores did not penetrate the whole layer of contemporary sediments.

Despite the insignificant length of the cores investigated by us, they enable us to state that the original rocks covered by the products of weathering sliding down the slopes lie beneath the contemporary sediments. At places the products which consist mainly of clay slide down the surface of original rocks. The coarse fragments found on the surface of the Central Elevation are the remains of the eroding mantle of the products sliding downward. The longer cores (7 cores longer than 100 m) obtained by P. S. Vinogradova (1946), part of which were taken from the Central Elevation, demonstrated that the underlying gray sediments had been enriched with carbonates and contain clayey schist and limestones; the pinkish-gray sediments are more uniform and they do not bubble when treated with HCl. The writer assumes that here we have to deal with the alluvium of original rocks.

It is necessary to investigate the Central Elevation with the aid of heavy bottom corers and to study in detail the coarse fragments.

In connection with the character of formation of contemporary sediments in the Central Elevation, the curve of the mean mechanical composition (table 11; fig. 60) shows the inflow of supplementary material in the

form of bands for particles ranging from 1 to 0.1 mm in the interval of sandy mud and for particles from 0.1 to 0.05 mm in the interval of muddy sand, as well as an increase of particles from 0.05 to 0.01 mm in the mud containing 30 to 40 % of particles smaller than 0.01 mm. On the average, the distribution with depth is regular.

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13. The Persey Elevation
(Vozvyshennost' Perseya)

The positive elements of bottom relief of the Barents Sea that are not directly associated with shores include the Persey Elevation with depths less than 200 m; its existence was established by the research of survey ship Persei (Persey) in 1928 and supported by further investigations carried out by survey ships Persei (Persey), Knipovich and by later depth soundings of PINRO. The Persey Elevation consists of two projections. The southeastern projection with depths reaching 160 m penetrates the Central Depression of the Barents Sea and is separated from the Central Elevation by a spur of the depression. The transverse depression - a trench between lat. 77°20' and 78° N - separates the elevation from the northeastern spur descending toward the plains of the Central Plateau. To the west the boundary of the Persey Elevation, due to the lack of measurement data, has been conditionally drawn along the long. 27° E of the northernmost part of the Western (Medvezhinskiy) Trench and along the extension of the trench of the Northern Plateau.

The existing data of bottom relief show that the surface of the Persey Elevation is covered with hills and intersected with trenches. On the basis of configuration of the 100-m and 200-m isobaths it can be assumed that the northeasterly direction of elevations is predominant, but in the spur at depths ranging from 200 to 250 m the northwesterly direction is pronounced, which is associated with outcrops of original rocks. The question remains open until we have carried out more thorough investigations. The bottom distribution by types[1] is presented on bottom charts (M. V. Klenova, 1932, 1948).

The sediments of the Persey Elevation are represented by all types - from sand to clayey mud; their color is pink as a result of intensive development of ferrous weathering (M. V. Klenova, 1936). The coarse fragments which are found in great quantities on the Persey Elevation, as in the case of the Central Elevation, are subject to weathering.

Sand, as a rule, is found at the smallest depths (St. 1043, 103 m, etc.). The muddy sand found at depths ranging from 114 to 243 m can be divided into two types according to the content of particles whose sizes range from 0.05 to 0.01 mm. The first type (less than 10% of fine silt) covers

[1]The data obtained during the following cruises of the survey ship Persei (Persey) have been used: the 5th cruise in 1924, 17th in 1928, 21st in 1929, 50th in 1934, by T. I. Gorshkova; 11th in 1926, by M. V. Klenova; 49th in 1934, by P. N. Novikov; during the following cruises of survey ship Knipovich: the 16th in 1930, by A. D. Dobrovol'skii: 24th in 1933, by K. A. Rachkovskaia; and during the 26th cruise of the survey ship Issledovatel' in 1940, by P. S. Vinogradova.

the slopes of a small ridge (St. 1237, 125 m; St. 1238, 134 m; fig 69), from the top of which a sample of sand was obtained, and part of the eastern slope of the Persey Elevation (St. 1241, 132 m, etc.). The muddy sand is uniform, pink, with ocherous spots and rings around the worm tubes, and with sandy rhizopods. The mean depth at which this type of muddy sand is found is 128 m. The muddy sand containing more than 10% of particles ranging from 0.05 to 0.01 mm is found at greater depths (the mean depth being 196 m) in the central (St. 2438, 176 m) and south-eastern (St. 2453, 243 m) parts of the Persey Elevation.

The most widely distributed sediment on the Persey Elevation is sandy mud. It covers the bottom of all the flat areas and slopes of underwater elevations at greater depths than the muddy sand. Among the coarser fragments (10 to 20% less than 0.01 mm in diameter) and finer fragments (20 to 30% of pelite) of sandy mud two types stand out: the well sorted sediment whose histogram is characterized by one apex and which has a clearly pronounced maximum of coarse silt particles, and the poorly sorted sediment containing admixtures of sand particles and coarse fragments whose histogram has two apices. A coarse-grained well sorted sandy mud verging on muddy sand is found in the western part of the elevation (St. 1024, 196 m), in the central part — near the areas covered /166 by muddy sand (St. 1030, 100 m) — and in the northern part (St. 574, 190 m, etc.; fig. 69, 5).

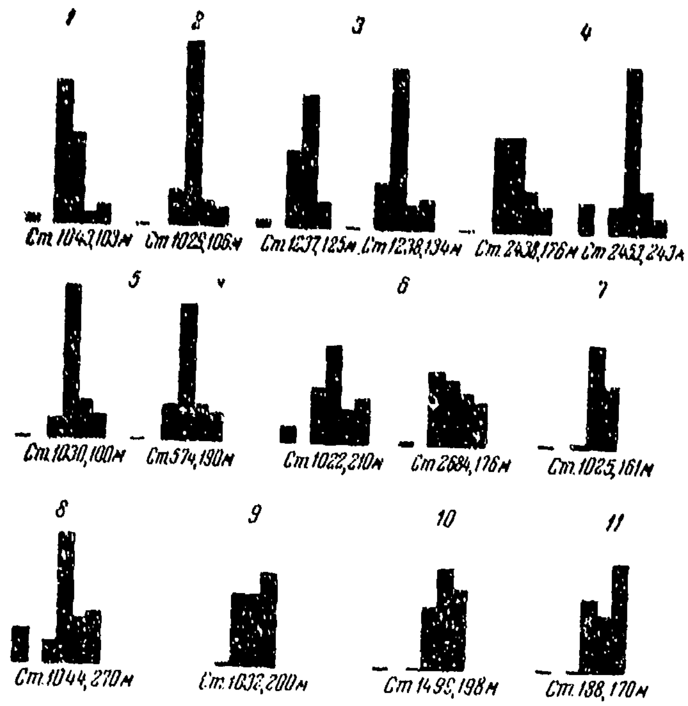


Fig. 69. Histograms of Sediments on the Persey Elevation.

1--sand (St. 1043, 103 m); 2--dust-sand (St. 1029, 106 m); 3--muddy sand with less than 10% of fine silt particles (St. 1237, 125 m; St. 1238, 134 m); 4--muddy sand with more than 10% fine silt particles (St. 2438, 176 m; 2453, 243 m); 5--sandy mud with up to 20% particles smaller than 0.01 mm, well sorted (St. 1030, 100 m; St. 574, 190 m); 6--the same mud, poorly sorted (St. 1022, 210 m; St. 2684, 176 m); 7--sandy mud, more fine-grained, whose histogram is characterized by one apex (St. 1025, 161 m); 8--the same mud whose histogram has two apices (St. 1044, 270 m); 9--mud whose histogram has one apex (St. 1032, 200 m); 10--the same with a maximum of fine silt (St. 1499, 198/184 m); 11--the same with apices in graphical presentation (St. 188, 170 m). (For explanation of symbols see fig. 33).

Toward the bottom of the cores the sandy mud loses its pink color, becoming light gray and greenish-gray. Everywhere it has an admixture of mica, sandy rhizopods and weathered stones consisting predominantly of pink sandstone with gypseous cement coated by iron oxide scales. The sandy mud found in the western part of the elevation in a closed depression (St. 1022, 210 m; St. 1024, 196 m), in the central part where abrupt changes in depth occur, near the slope of the central trench (St. 1240, 167/153 m), on the surface of the southeastern spur, on a relatively steep southern slope (St. 2486, 176 m and a number of others) has an increased quantity of sand particles and sometimes the graphical presentation of its mechanical composition has two apices. In such cases it happens that even in the cores of a limited length (to 30 cm) the lower layer contains a more fine-grained sediment of gray or pinkish-gray color with a considerable admixture of gravel, shingle and fragments of shells. /167
The shingle and gravel is composed of limestone and black schist.

The fine-grained sandy mud whose graphical presentation has one apex (St. 1025, at 161 m, for instance) lies on the periphery of an elevation where ferro-manganese concretions are formed. Changes in the color and composition of sediments occur gradually down the core. On the contrary, the sandy mud whose graphical presentation has two apices (St. 1044, 270 m; St. 1027, 180 m, etc.) covers the bottom of the western and southwestern parts of the Persey Elevation near the Western Trench (Zapadnyy Zhelob). The cores show the stratification of the sediment. In the upper layer there is a considerable admixture of gravel, shingle and detritus, which

consists mostly of completely weathered rocks - namely, pink, fine-grained, micaceous sandstone, basalt, gray sandy schist and limestone which has been entirely replaced by brown oxides. The sediments lying at the base of the southern slope of the Persey Elevation are similar to glacial materials deposited on steep slopes and fjords.

Flat lower areas are covered by mud. A graphical presentation having one apex with a maximum of clay (St. 1032, 200 m, for instance) has been derived from cores containing Recent sediments from top to bottom (maximum up to 38 cm), whereby in downward direction the core becomes more clayey, assuming a brighter color with a slightly pink hue and containing a small amount of fragments. Mud containing a maximum of fine silt (St. 1499, 198/184 m) lies on the southern slope of the elevation. The mud found on the steep northern slope of the elevation and being represented graphically with two apices (St. 188, 170 m, etc.) lies on a bluish gray mud, verging on clayey mud, which differs sharply from the upper layer.

The samples of clayey mud taken from the northwestern part of the elevation (at St. Ca 1505, 195 m, for instance) are from the underlying layer which here either reaches the surface or is covered by a thin layer of Recent sediment. A greater quantity of sand particles (the mean being 4.5%) in the clayey mud attests favorably to its earlier origin.

As in the case of other areas having a complex relief, the thickness of contemporary sediments on the Persey Elevation decreases on its slopes and sometimes also on the surface of elevations. Thus from a relatively

steep slope of a small ridge in the eastern part of the elevation (St. 1237, 125 m) we obtained a core containing more clayey material of rosy-gray color with gravel of black schist as well as shingle of white limestone which was lying 5 cm beneath the pink muddy sand. The bottom grab, however, brought up from the place only a great quantity of gravel and shingle lying in a dense and heavy sandy mud of rosy-gray color. A number of cores taken from under a layer of 3 to 5 to 12 cm thick muddy sand of the southeastern spur of the Persey Elevation disclose an interstratification of muddy sand with gray mud enriched with carbonate fragments and gravel (St. 2455, 240 m, etc.; fig. 70). A mixed transitional layer is also sometimes observed near the Western Trench (St. 1027, 180 cm) where a layer of pink sandy mud 7 cm thick lies on an interstratification (13 cm thick) of gray and pink mud. The thickness of oxidized layers is 2 to 3 mm. The sediment contains many carbonaceous deposits and when dry it is porous.

At a depth of 132 and 131 m in the western part of the Persey Elevation, P. S. Vinogradova (1946) found a very carbonaceous brick-red sediment of pinkish-gray color and irregular stratification with detritus of calcareous rocks, but 30 miles to the north at another station she found a gray sediment with black veins and shingles of soft black clayey schist which was replaced by a black clayey material at a depth of 16 cm in the core; it consisted of individual uniform areas covered by fragments of black /168
clayey schist with pyrite. Both types of sediment were overlain by a greenish-gray sandy mud 6 to 7 cm thick and having a pinkish-gray color

at surface. Near the southern slope in a core 88 cm long P. S. Vinogradova found pinkish-gray mud merging with a coarser gray and light-gray sand with thin weathered coatings and shingles of sandstone whose quantity increased downward. In the lower part of the core the size of angular fragments of sandstone varies from 2 to 4 to 5 cm and they look fresher. In other words, under a rather thin layer of Recent sediments lie original rocks and the materials of their weathering. Among the cores collected by the Poliarnik Expedition in 1953 to the west of the Central Trench of the Persey Elevation at a depth of 170 m a sample disclosed glacial alluvial deposits (St. M 122; fig. 70) consisting of sandy rhizopods, gravel, and remains of chitins. Beneath it lies sandy mud with gravel and fragments of coal increasing in quantity from 13 to 14 cm; beneath the latter lies sand with bright-colored sandstone shingle. On the southern slope of the Central Trench the same type of clay is found at a core depth of 9 cm; there is also found another glacial alluvial deposit at a depth of 5 cm in the area; but 30 miles to the south at a depth of 127 m (St. M 124) the layer of glacial alluvial deposits is 5 cm thick, lying directly on the surface of a dense, heavy and micaceous clay.

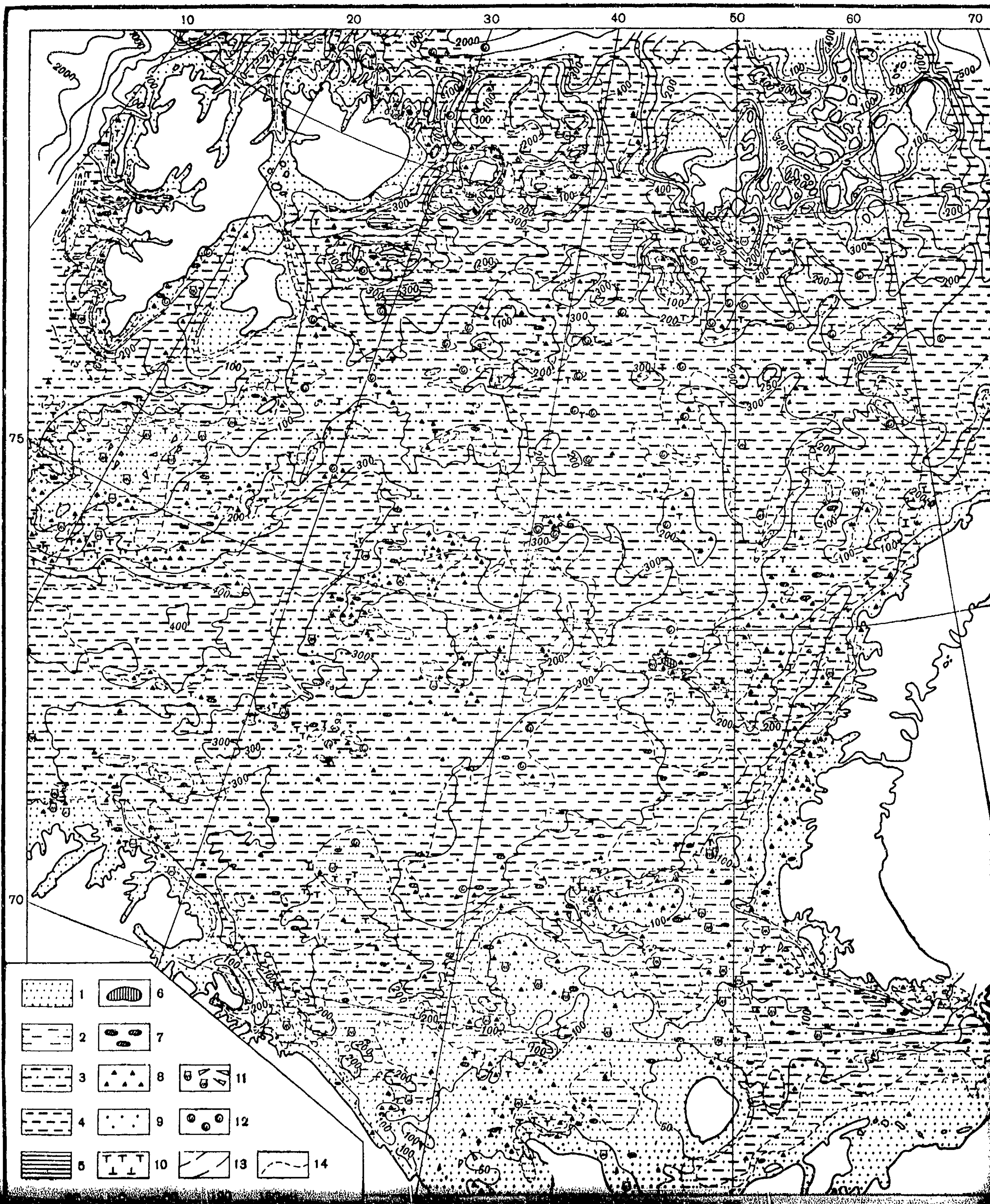
The graphical presentation of the mean mechanical composition of sediments covering the Persey Elevation (table 11) is characterized by a consecutive decrease of particles ranging from 1 to 0.1 mm and from 0.1 to 0.05 mm and by slight curves. An increase in the quantity of particles ranging from 0.05 to 0.01 mm in the interval of mud with 30 to 40% of fine particles reflects supplementary inflow of fine silt particles as a result of the erosion of lower layers (fig. 60).

Fig. 70. Cores of the Persey Elevation.

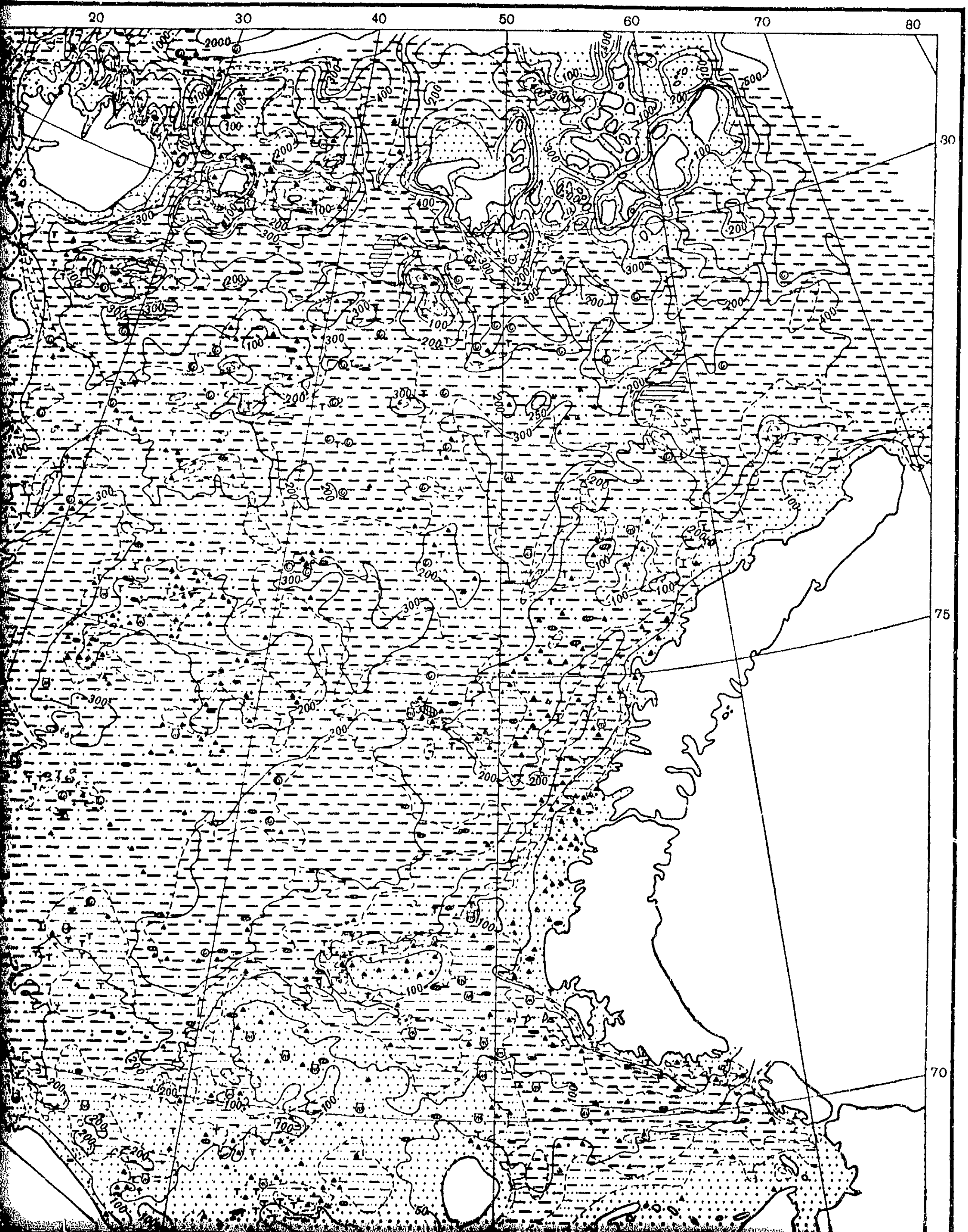
1 -- irregular interstratification of greenish-gray sandy mud and muddy sand with gray mud (at 16 to 21 cm of core; St. 2455, 240 m); 2 -- transitional layer: interstratification of gray and pink sandy mud (at 2 to 18 cm of core; St. 1027, 180 m). At the bottom -- gravel composed of schist; 3 -- core 19 cm long (St. M 122, 170 m) in the central part of the Persey Elevation. The glacial alluvial layer on the surface and the transitional layer at 13 to 14 cm of core.

A

B



B



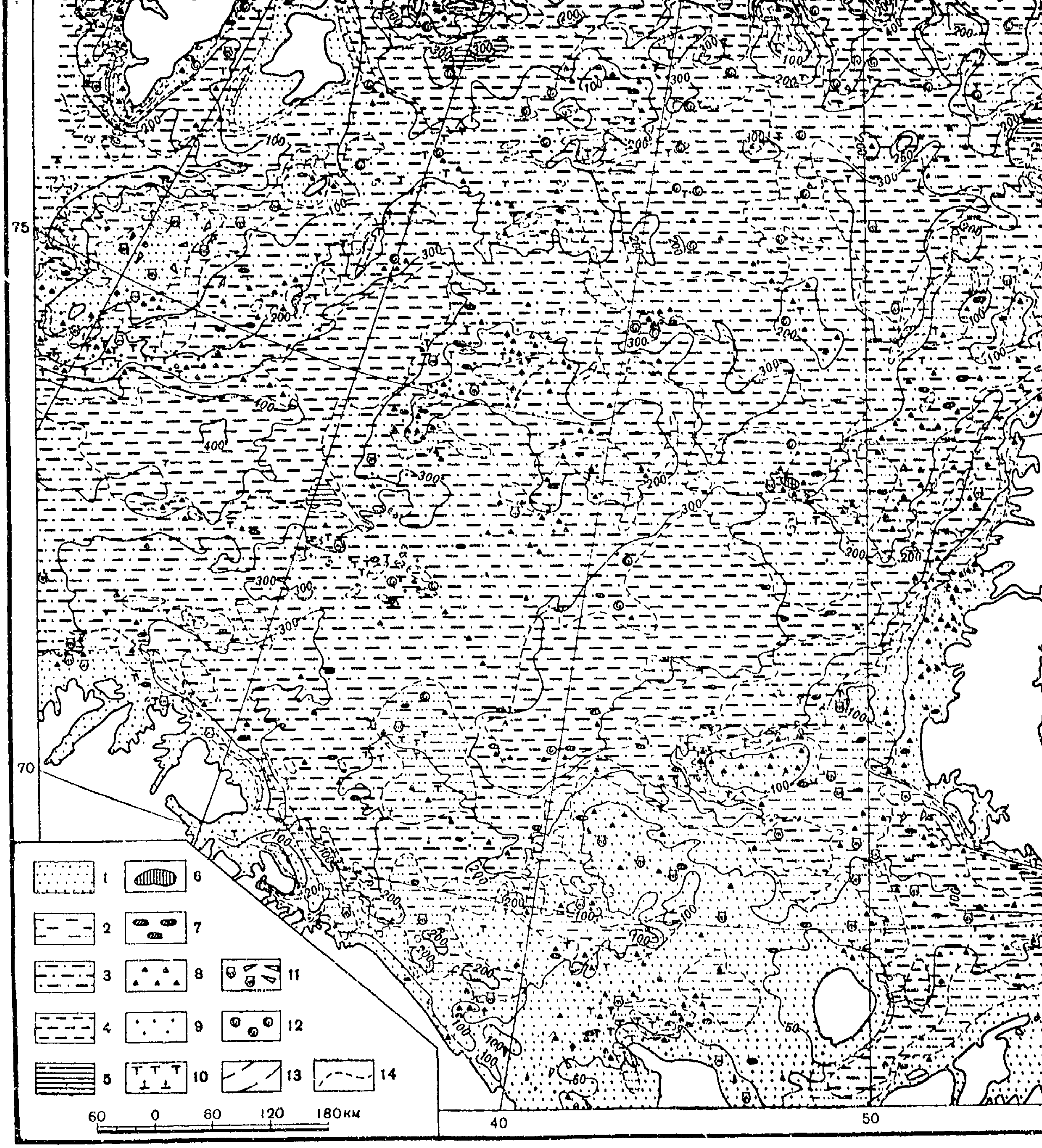


Fig. 71. An outline chart of Barents Sea floor.

1 -- sand; 2 -- muddy sand (a -- pink and pinkish-gray;b -- greenish-gray and gr
mud (a -- pink and pinkish-gray;b -- greenish-gray and gray); 4 -- mud (a -- pin
gray; b -- greenish gray and gray); 5 -- pink clayey mud; 6 -- old clay; 7 -- bo
shingle and detritus; 9 -- gravel; 10 -- large stones; 11 -- shells and their fr
concretions (pebbles); 13 -- isobaths; 14 -- boundaries of bottom type areas.

Prepared by M. V. Klenova on the basis of bottom surveys from 1923 to

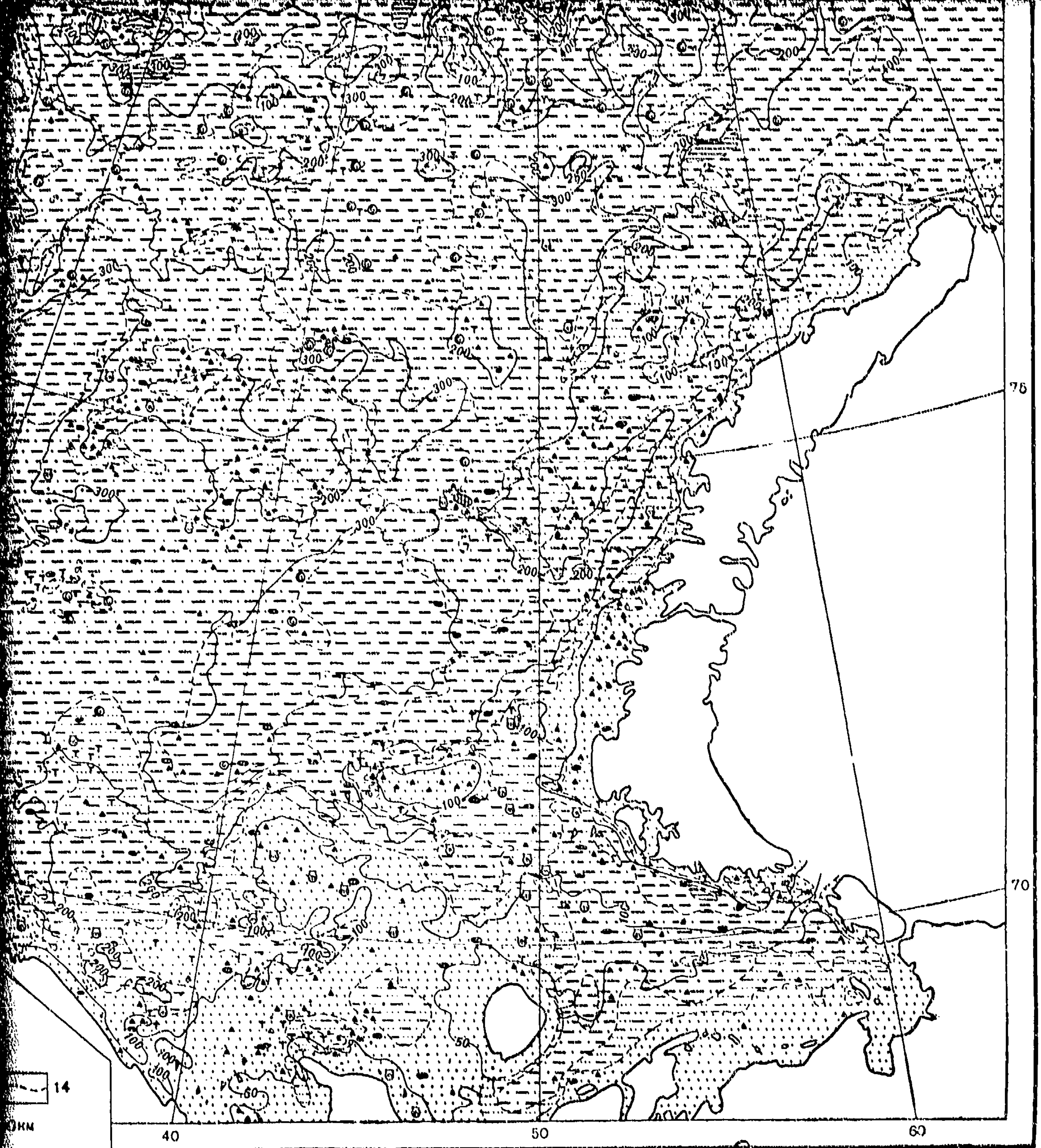


Fig. 71. An outline chart of Barents Sea floor.

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itus; 9 -- gravel; 10 -- large stones; 11 -- shells and their fragments; 12 --
bles); 13 -- isobaths; 14 -- boundaries of bottom type areas.

ed by M. V. Klenova on the basis of bottom surveys from 1923 to 1953.

14. Medvezhinskaya Shoal (M. banka).

The Bear Shoal (Medvezhinskaya Shoal) or the Medvezhinsko-Nadezhdinskoye Shoaling Water (melkovod'ye) lies between the Western-Medvezhinskiy Trench and the coastal areas of Spitsbergen Archipelago. The minimal depths in the southern portion of the area are found around Bear Island (Bjørnøya or ostrov Medvezhiy) itself representing a remnant of a platform with almost horizontal beds of upper Paleozoic and Mesozoic rocks. The southern portion of the base of Bear Island (Bjørnøya or ostrov Medvezhiy) slopes steeply westward to the great depths of the Greenland Sea and southward to the Western Trench of the Barents Sea. The slopes are intersected by trenches. Also terraces can be observed, especially the ones which are well pronounced near the 200-m isobath and which surround the old shore line (M. V. Klenova, 1931). The trenches penetrating deeply from the west and the east separate the southern portion of Medvezhinskaya Shoal (M. banka) from the shoaling water extending in NNE direction toward Hopen Island (ostrov Nadezhdy). On the so-called Spitsbergen Bank (Spitsbergen banken) in the central portion of the shoaling water, the depth varies from 50 to 30 m, and at places to 17 m. The bottom relief has not been sufficiently investigated. The Spitsbergen Bank (Spitsbergenbanken) slopes gently toward the Western Trench in the east and toward the wide Zuid-Kapp (Sørkapp) Trench in the northwest. The latter separates the Medvezhinsko-Spitsbergen Shoaling Water from the base of Spitsbergen Archipelago. At a depth of 200 m the underwater slope in the area is intersected by trenches which were evidently formed during the early stages

of development of the given area because many of the trenches do not extend to shallow depths. It is possible that detailed measurements will enable us to disclose them there also (i.e. at shallow depths. Tr.). The northern portion of the shoaling water surrounding the Hope Island (Hopen) borders on the Persey Elevation in the east, on a depression to the south of Kong Karls Land in the north and on the base of Edges Island (Edgeøya) in the west. The border between Medvezhinskaya Shoal (M. banka) and Western Trench runs along the 250-m isobath. In addition to the submerged shore line and underwater terrace delineated by the 200-m isobath, benches having a rather smaller width have been disclosed at great depths on the southern and western slopes of the Medvezhinskaya Shoal (M. banka). Here, as in the case of Spitsbergen slope farther to the north, the underwater benches have been discovered at the depths of 400, 500 and 900 m (M. V. Klenova, 1939).

At a depth of 100 m the surface of Medvezhinskaya Shoal (M. banka) is covered by coarse fragments[1] — boulders, shingle, detritus and gravel with a considerable quantity of shells and fragments of mollusks, barnacles and other organic remains, as well as live organisms (fig. 71). On the slope one can observe sand sliding down the steep western slope to a depth of 165 to 187 m (St. 2024) and to 172 m (St. 1889). The sand is characterized by poor sorting (fig. 72), and by a greenish-gray color; it is

[1]The data were obtained during the following cruises of survey ship Persei (Persey): 7th in 1925, 12th in 1927, 45th in 1933 by T. I. Gorshkova; 19th in 1929, by K. R. Olevinskii; 28th in 1930 by V. P. Zenkovich; 35th in 1931 by L. A. Iastrebova and E. K. Kopylova; 37th in 1931 by M. V. Klenova and I. K. Avilova; 40th in 1932 by V. P. Zenkovich and E. K. Kopylova; 43rd in 1933 by P. N. Novikov; 54th in 1935 by S. I. Malinin and Kuzovleva; 70th in 1938 by O. N. Kiselev; during the 16th cruise of survey ship Knipovich in 1930 by A. D. Dobrovol'skii.

saturated with rhizopods and other carbonate remains, including the shells of *Mya truncata*, *Astarte sp.*, *Leda pernula*, spines of sea urchins, worm tubes and agglutinative forms of rhizopods.

Among the minerals quartz in large, smooth grains is predominant; feldspar is also found. The same content is found in the muddy sand covering the slopes at a depth of 150 m to 250 m (St. 1886, 245 m, on the steep southern slope). Below the muddy sand on the slopes is sandy mud. It is greenish-gray in color and contains numerous organic remains and carbonate fragments. It contains gravel and shingle composed of intensely weathered pink sandstone with gypseous cement, gray clayed and carbo- /170
naceous schist, gray quartzite, dark micaceous sandstone and other rocks of local origin. The degree of sorting of the sandy mud varies: at shallow depths and near the old shore line the quantity of sand particles increases (St. 331, 87 m, in a depression of the surface of the shoal; St. 1907, 223 m on the southeastern slope, etc.; fig. 72). The coarser sandy mud, as well as the muddy sand, which lies on steep slopes or at places where the depth variation is abrupt, is characterized by the appearance of two vertexes in the graphical presentation of mechanical composition (for instance, at St. 2012, 174 m on the southern slope of Medvezhinskaya Shoal (M. banka); at St. 1891, 162/187 m[1] on the western slope of the Spitsbergen Bank (Spitsbergenbanken) and at other stations on the underwater cape in the deep trench separating the Medvezhinskaya Shoal (M. banka)

[1]Because of steepness of the slope the depth varied while the station was occupied.

from the Spitsbergen Bank (Spitsbergenbanken); at St. 1911, 207 m, on the eastern slope and at a number of other stations; fig. 72).

A more fine-grained sandy mud (20 to 30% of particles smaller than 0.01 mm) is represented by several graphical types. The sandy mud whose graphical presentation has one apex is rather widely distributed; the fragments constituting it are equally distributed (St. 1909, 210 m; St. 1924a, 272 m and a number of others on the gentle slope extending to the Western Trench and on the southern slope of Zuid-Kapp (Sørkapp) Trench; fig. 72). The graphical presentation of the sandy mud covering steep slopes and underwater valleys (trenches. Tr.) has two apices as in the case of more coarse-grained sediments (St. 2007, 147 m, on the southern slope of Medvezhinskaya Shoal; St. 1893, 197 m and St. 1891a, 137 m on the western slope near an underwater valley and a number of others; fig. 72). In areas that were more protected, e. g. on the slope of the northern portion of the Western Trench, on the extreme eastern spur of /171 the Zuid Kapp (Sørkapp) Trench, sandy mud with a maximum of fine silt is deposited (St. K 122/3, 187 m; fig. 72.7) which attests to a considerable degree of cementation. The same type of mechanical composition characterizes the mud on the mentioned eastern slope (St. 1921, 208 m; fig. 72, 8). At shallower depths a mud was found whose mechanical composition is represented by a graph with two apices (St. 1181, 193 m) or by an almost equi-apexed graph (St. 318, 140 m; fig. 72, 9).

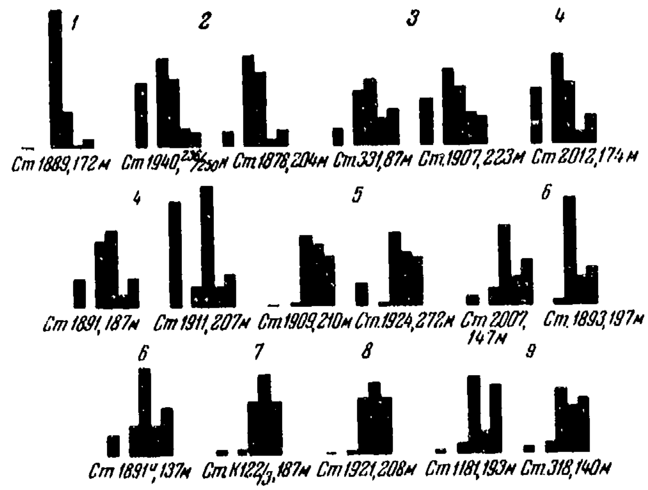

Fig. 72. Types of mechanical composition of sediments on the Medvezhinskaya Shoal (M. banka).

1 -- sand (St. 1889, 172 m); 2 -- muddy sand (St. 1940, 236/250 m; St. 1887, 204 m); 3 -- sandy mud (St. 331, 87 m; St. 1907, 223 m); 4 -- sandy mud on steep slopes (St. 2012, 174 m; St. 1891, 187 m; St. 1911, 207 m); 5 -- sandy mud, more fine-grained (St. 1909, 210 m; St. 1924d, 272 m); 6 -- fine-grained sandy mud on slopes (St. 2007, 147 m; St. 1893, 197 m; St. 1891a, 137 m); 7 -- sandy mud with a maximum of fine silt (St. K122/3, 187 m); 8 -- mud of the same type (St. 1921, 208 m); 9 -- mud which is expressed by two apices and equi-apexed graphs (St. 1181, 193 m, 2nd core; St. 318, 140 m). For the explanation of symbols see fig. 33).

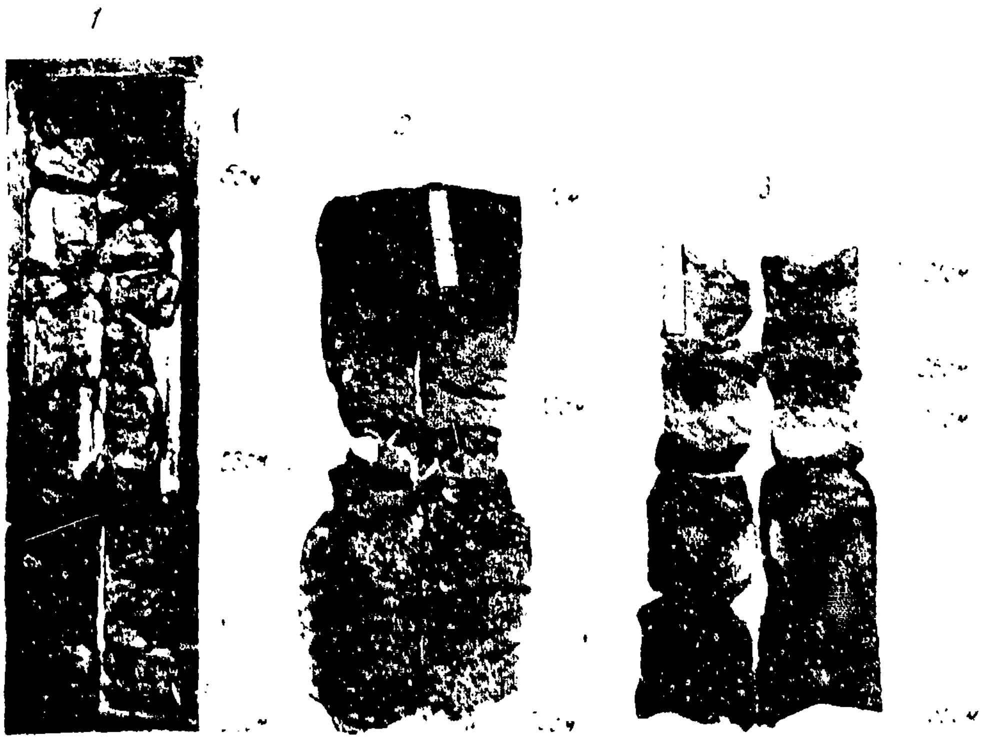

Fig. 73. Cores taken from Medvezhinskaya Shoal (M. banka).

1 -- a core 32 cm long from the southeastern slope of the Medvezhinskaya Shoal (St. 1927a, 164 m). At the depth of 1 to 4 cm one can observe greenish-gray muddy sand and sandy mud; at 5 to 22 cm, bluish-gray clay with shingle and carbonate remains; at 23 to 29 cm, a mixture of clay with greenish-gray sandy mud; at 30 to 32 cm, greenish-gray muddy sand; 2 -- a core 20 cm long (St. 1924, 234 m). Greenish-gray sandy mud with worm burrows and pores on a bluish-gray sandy mud with gravel; at 11 to 12 cm, a semidissolved shell; 3 -- the second core of St. 1181, 193 m. The greenish-gray mud lies on a bluish-gray sandy clay; at 25 cm, a buried oxidized layer; at 26 cm, a rough surface of the underlying layer.

The thickness of Recent sediments covering the Medvezhinsko-Spitsbergen Shoaling Water is negligible. Due to active wave and current action, the fine-grained material is washed out at places from the slopes so that only a thin coating of submarine material that slides down the slopes and is mixed with gravel and shingle remains on them. Therefore most of the cores are short, from 10 to 15 cm long. Even the bottom corer of Ubekochernaz type weighing more than 300 kg (St. 2022, 239 m, on the southwestern slope) obtained a core only 17 cm long, consisting of muddy sand with broken shells, gravel and shingle and gray dense sandy mud, in which the coring tube was bent at a right angle reaching it because, evidently, bedrock lay beneath. The cores taken from areas covered by /172 sandy mud are somewhat longer — 20 to 21 cm, the bottom is covered with gravel and shingle, which obstructs the penetration of the bottom corer. On gentle slopes the length of cores reached 29 to 31 cm stopping upon reaching the shingle or in the dense underlying layer whose components were detected on the end of the bottom corer. Sometimes (at St. 1937, 238/215/173 m[1], on the steep southern slope, for instance) a sample core ended in a compact layer of gravel and shingle with an admixture of clayey material, i.e. on the layer of glacial alluvium. On the western slope the Recent layer, only 1 cm thick, was underlain by gray, slightly rosy-colored marl which was dense, heavy and non-saline containing carbonaceous remains that were not identified in detail. In the calm areas of Zuid Kapp (Sørkapp) and the Western trenches the cores up to 45 cm long did not penetrate the Recent layer.

[1]The depth varied while the station was occupied.

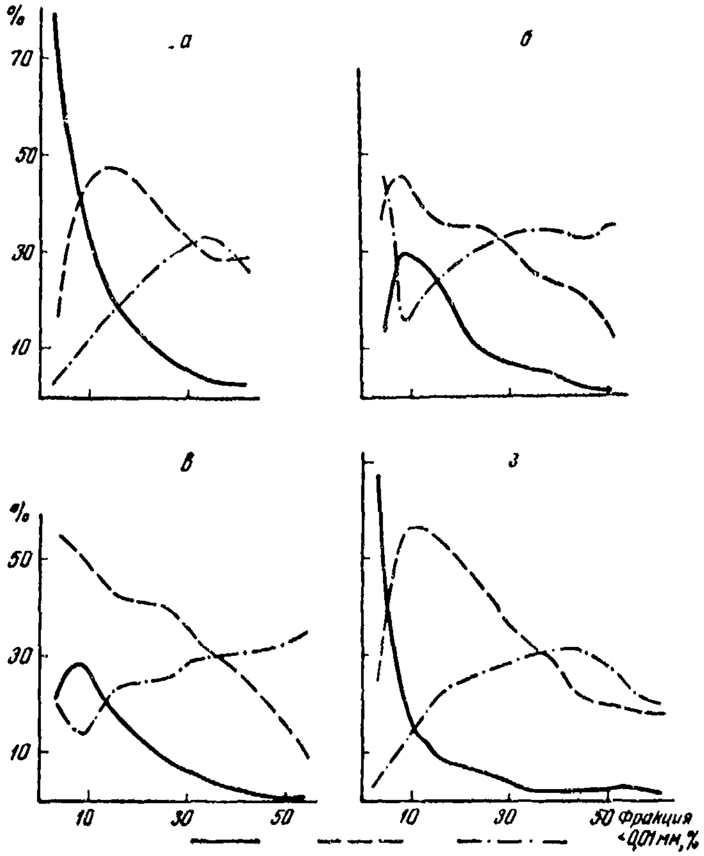

Fig. 74. The mean mechanical composition of sediments of the northern and northwestern portions of the Barents Sea in areas affected by glacial deposits.

a -- 14th area, Medvezhinskaya Shoal (M. banka); б -- 15th area, Spitsbergen Slope; в -- 16th area, Polar Basin Slope; г -- 17th area, Northern Plateau. Fragments: 1 -- 1.0 to 0.1 mm ; 2 -- 0.1 to 0.05 mm; 3 -- 0.05 to 0.01 mm.

Key. Lower right-hand corner: Fragments
$<$0.01 mm,%

The complex stratification, which was, of course, at places associated with landslides, was observed in a number of cores obtained from the southeastern slope. Such is, for instance, the core taken at St. 1927a

(164 m; fig. 73) where the greenish-gray layer of mud, 5 cm thick, is underlain by a bluish-gray mud of sandy clay with gravel, reaching the depth of 23 cm; at the depth of 23 to 25 cm one can observe a blend of the clay with a sandy mud, and lastly, at the bottom of core, 30 to 32 cm deep, again greenish-gray muddy sand which differs from the upper layer. The same pattern is observed at other stations of the area. The underlying light-gray sandy mud is replete with gravel of gray schist and gray and white sandstone. Sometimes the greenish-gray upper layer is underlain by a dense and heavy sediment of rosy-gray color with gravel and shingle of light glauconitic (quartz) sandstone (St. 1917, 157 m). The major part of the cores obtained from the central section of the eastern slope had not penetrated the contemporary layer, but at St. 1924c (234 m) porous, greenish-gray mud was found at a depth of 13 cm; it was lying on a rough surface of a dense rock consisting of clay with gravel and ocherous particles.[1] The core taken at St. 1811 (193 m) disclosed a buried oxidized ocherous layer at the interface between mud and bluish-gray sandy clay (fig. 73).

The graph of mechanical composition (table 12) for the area of Medvezhinskaya Shoal is in complete agreement with the characteristics of sedimentation described above: with increase in the quantity of particles smaller than 0.01 mm, the curve of sand particles decreases uniformly

[1]Due to the denseness of the lower layer, it did not decrease in diameter when becoming dry, which can be clearly seen from the photograph.

from very high values (79.7% for sand) (fig. 74). Because of inflow of supplementary material on slopes, the particles of coarse silt, when expressed graphically, form curves in the muddy sand and sandy mud range, but the particles of fine silt form curves in the mud range. The depth of distribution of individual types fluctuates irregularly and the coarse-grained sediments sink to very great depths due to the active hydrodynamical regime.

Table 12

THE MEAN MECHANICAL COMPOSITION OF SEDIMENTS IN THE NORTHWESTERN PART OF THE BARENTS SEA

Bottom Type	Fragments <0.01 mm in %	Depth in m		Particles in mm					Number of Analyses
		from-to	mean	>1	1-0.1	0.1--0.05	0.05--0.01	<0.01	
Medvezhinskaya Shoal									
Sand	<5	100-187	145	(6,7)	79,8	16,4	1,3	2,5	3
Muddy Sand	5-10	55-327	179	(15,7)	40,2	43,7	8,7	7.4	14
Sandy Mud	10-20	57-320	174	(18,1)	17,4	47,8	19,1	15,7	57
" "	20-30	93-1000	214	(8,0)	8,9	39,1	28,0	24,0	57
Mud	30-40	84-235	162	(3,8)	3,6	30,3	33,0	33,1	14
"	40-50	145-248	193	(2,3)	2,1	29,6	26,8	41,5	3
Underwater Slope of Spitsbergen									
Sand	<5	—	300	(25,1)	13,6	36,2	45,4	4,8	1
Muddy Sand	5-10	25-200	113	(8,7)	30,5	45,4	16,1	8,0	2
Sandy Mud	10-20	60-800	262	(19,8)	23,5	36,5	24,2	15,8	20
" "	20-30	35-820	226	(13,6)	8,4	35,1	31,2	25,3	28
Mud	30-40	57-1000	230	(8,6)	5,8	26,0	34,7	33,5	32
"	40-50	88-424	245	(9,7)	1,9	21,0	32,4	44,7	10
Clayey Mud	>50	—	147	(4,7)	2,1	13,2	34,7	50,0	1

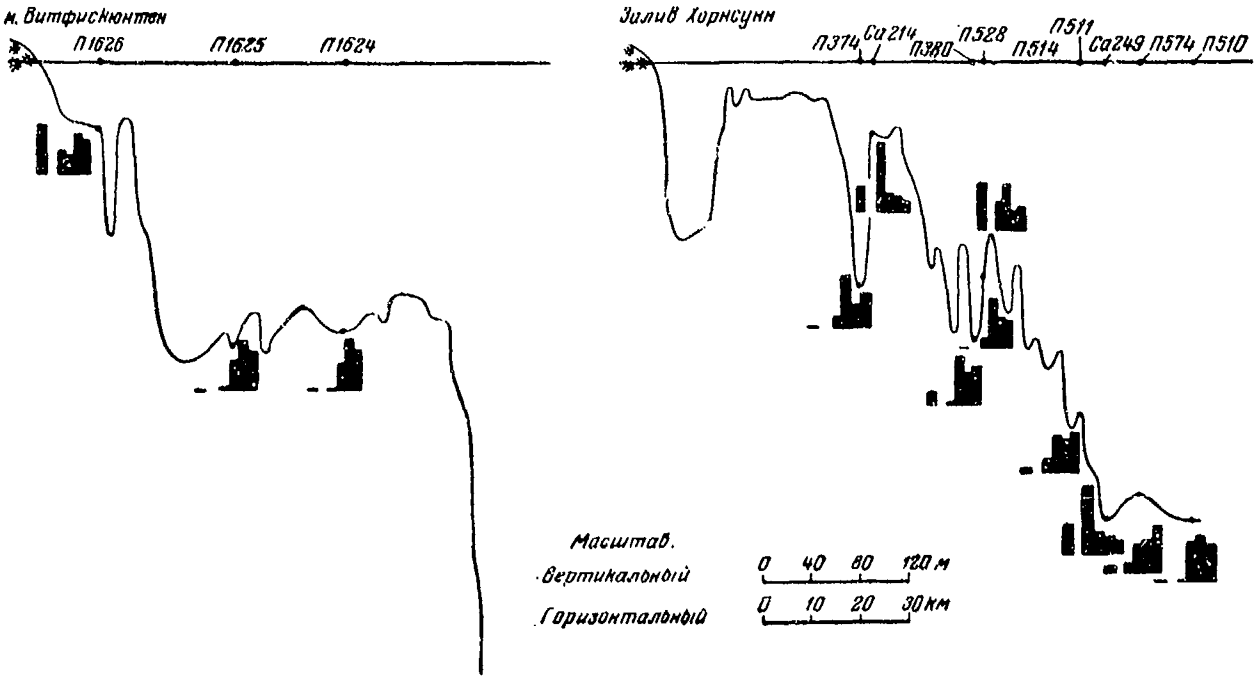

Fig. 75. Distribution of Sediments by Mechanical Composition on Underwater Slopes of Spitsbergen. (For explanation of symbols see fig. 33).

Key. Upper left-hand corner: Cape Vitfiskjunten*

Upper center, right: Gulf Hornsund

Lower center: Scale.
Vertical
Horizontal

*(not identified with other sources)

15. The Spitsbergen Underwater Slope

The Spitsbergen Underwater Slope has been singled out by us because of the peculiarity of its morphology and geological structure as well as because of the characteristics of sediments which have left specific marks of glacial denudation processes. To the south, the area includes the northern branch of the Zuid Kapp (Sørkapp) Trench entering the Storfjord (Storfjorden). The eastern boundary runs along the 50-m isobath bordering on the Edge (Edgeøya) and Barents (Barentsøya) islands and extending farther to Cape Mon (Mys Mon) of the North-Eastern Land (Nordaustlandet) of Spitsbergen. To the west the area includes the slope extending toward the Greenland Sea and to the north the boundary has been drawn along the lat. 80° N.

The morphology of the underwater slope of Spitsbergen, notably in the west, is very complex; there are numerous fjords with branches, including underwater and terrace-like benches, banks, under- and above-water rocks which obstruct navigation near the coast and cause a variegated distribution of sediments. In fjords and on slopes, the sediments are represented mainly by sandy mud, less frequently by muddy sand, mud and clayey mud in isolated sections of fjords.[1] All the types of sediments are replete with coarse fragments, containing great quantities of sand particles and

[1]The data obtained during the following cruises of survey ship Persei (Persey): 5th in 1924, 7th in 1925, 50th in 1934 by T. I. Gorshkova; 37th in 1931 by M. V. Klenova and I. K. Avilov; 43rd in 1933 by P. N. Novikov; 54th in 1935 by S. I. Malinin and Kuzovleva; during a cruise of expedition ship Sadko in 1935 by M. M. Ermolaev.

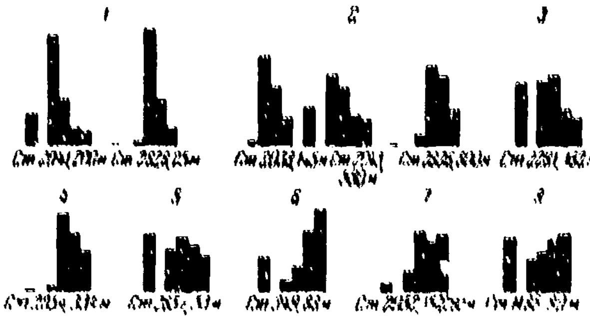

Fig. 76. Types of Mechanical Composition of Sediments on the Underwater Slope of Spitsbergen.

1--muddy sand (St. 2041, 200 m; St. 2828, 25 m); 2--sandy mud (St. 2038, 145 m; St. 2043, 580 m; St. 2826, 800 m); 3--sandy mud with admixture of coarse fragments (St. 2281, 162 m); 4--more fine-grained sandy mud (St. 2054, 334 m); 5--poorly sorted sandy mud (St. 2857, 53 m); 6--mud whose graph of mechanical composition has one apex (St. 349, 88 m); 7--mud whose graph of mechanical composition has two apices (St. 2052, 152/282 m); 8--poorly sorted mud (St. M86, 80 m). (For explanation of symbols see fig. 33).

poorly sorted (fig. 75). Well sorted muddy sand is found only in individual areas, for instance at St. 2828, 25 m in the Kings Bay (Kongsfjorden), where it consists of quartz with a small admixture of feldspar, mica and non-ferrous minerals, such as hornblende, zircon and others. The muddy sand lying in the Icefjord (Isfjorden) cross section (St. 2041, 278/200 m; fig. 76) of the Greenland Sea is characterised by considerably poorer sorting and by many coarse fragments. Here the muddy sand was obtained at a shallower depth, but the sandy mud of the same type and having one apex in graphical presentation was obtained at a greater depth. The shingle of quartz sandstone and pink sandstone with gypsum cementation /176
bears the traces of marine fouling. A sample taken by bottom dredge was

also characterised by a variegated assortment of fragments, such as grey sandstone, diabase (? in the Russian original. Tr.) clayey schist, chloritic schist, phyllite and a multitude of Fornaminifera. At a depth of 800 m, a considerable amount of spines of sponges was found, but at smaller depths lithothamnia (St. 2050, 270 m).

In sandy mud were found the same types of mechanical composition as in the areas described above. On gentle underwater slopes, at the exit from Bel Sound (Bellsund; St. 2038, 145 m; St. 2043, 580 m) or Ice Fjord (Isfjorden; St. 2827, 236 m; St. 2826, 800 m) for instance, a relatively well sorted material is deposited; the graph of its mechanical composition has one apex (fig. 76). Near the Zuid Kapp (Sørkapp; St. 2281, 162 m; fig. 76, 3) and on underwater ridges and shoals between trenches a multitude of coarse fragments and sand particles is found. With increase in depth, in each individual area one can observe an increase in the content of pelitic particles; however, a considerable admixture of coarse-grained material is preserved and the assortment becomes less pronounced (at St. 2054, 334 m, on the slope of Zuid Kapp (Sørkapp) Trench, for instance; fig. 76, 4). On steep slopes one can observe the appearance of sediments whose mechanical composition is expressed by a graph with two apices (St. 2052, 152/282 m; fig. 76, 7); sometimes they are confined to the bottoms of fjords (fig. 75). A poorly sorted sandy mud and a mud containing an almost equal quantity of all particles are accumulated in locked areas at shallow depths, in Hinlopen Strait (Hinlopenstretet) for instance (St. 2857, 53 m; fig. 76, 5). An analogous composition is observed in the

dark-gray clay with gravel and detritus of black carbonaceous schist on the slope of Barents Island (Barentsøya; St. M86, 80 m) which represents an accumulation of glacial alluvial deposits. At the eastern coast of Edge (Edgeøya) Island one can observe gray sandy mud of the same type (St. M84, 20 m) lying under a very thin layer of gravel formed from fragments of gray, porous sandstone and coarse sand.

In almost all of the cores, the greenish-gray sandy mud is gradually replaced by a dark-gray mud toward the bottom. At a depth of 800 m, a more clayey material begins at the 42-cm mark of a core 70 cm long and at the bottom it merges again with a coarser material (St. 2826). At a depth of 280 m (St. 3296; fig. 77) on the slope of Zuid Kapp (Sørkapp) Trench one can observe glacial alluvial deposits consisting of a dense and heavy pinkish-gray clay with gravel lying under a layer of sandy mud 15 cm thick. At a depth of 334 m, i.e. down the slope, a lighter sediment of analogous composition has been found at the 7-cm mark of core (St. 2054).

A considerably more uniform and better sorted material - namely, mud and clayey mud - accumulates in the Stor Fjord (Storfjorden; St. 349, 88 m), which is evidently furthered by the stagnant hydrological regime under the stable ice cover. The quantity of carbonaceous remains is smaller here than on the western slope — in the area affected by the Atlantic water. The Calcareous rhizopods are absent here.

Fig. 77.

Glacial alluvial deposits of original rocks on the slope of Zuid Kapp (Sørkapp) Trench. A core 25 cm long (St. 3296, 280 m).

The graph of mechanical composition (table 12) in the Spitsbergen area and in other coastal areas is distinguished by bends in the curves of all particles that characterize the accumulation of material drawn from various sources (fig. 74). The convexity of the curve for sand in the mud interval is associated with samples obtained from fjords. The depth range is very wide due to the steepness of slope of the Greenland Sea and the presence of isolated depressions in the relief of Continental Shelf.

16. The Polar Basin Slope

The Polar Basin Slope adjoins the Barents Sea, though, according to the generally accepted boundaries, it does not enter the confines of the latter. As the southern border of the area we consider the northern shores of Spitsbergen and the line running along the water divide between submarine valleys pointed toward the north into the Arctic Basin and toward the south in the direction of the Northern Plateau of the Barents Sea. The boundary runs a little to the north of the Belyj Island (Kvitøya) and Viktoriya Island (ostrov Viktoriya), ending at Cape Meri Kharmsuort (Mys Meri Kharmsuort) of Franz Joseph Land and running farther through the archipelago.

The general character of bottom relief is completely clear, though our knowledge of it is far from satisfactory.[1] The slope is intersected by

[1] The results of measurements conducted by GUSMP and the bottom samples collected by V. D. Dibner in 1956-1957 were not at our disposal.

trenches (M. V. Klenova, 1945, 1948) descending to great depths of the Arctic Basin. One of them, as can be assumed from a study by Nautilus, is the extension of the Hinlopen fracture continuing northward into a deep depression to the west of Franz Josef Land Shoaling Water. A branch of the trench runs toward the Vide Fjord (Wijdefjorden). One can trace such trenches as are adjacent to the Wood Fjord (Woodfjorden) at the Western Spitsbergen and to the Rijps Fjord (Rijpfjorden) and the Dover Fjord (Duvefjorden. ? Tr.) at Northeast Land (Nordaustlandet).

Farther to the east, depths exceeding 400 m have been found between the Bol'shoy Island (Bol'shoy ostrov) at the Northeast Land (Nordaustlandet) and the Belyj Island (Kvitøya) where the valley is separated by a threshold 137 m deep from a valley 344 m deep stretching northward in an almost north-south direction on the North Plateau of the Barents Sea. To the north of Belyj and Viktoriya islands (Kvitøya and ostrov Viktoriya) at a depth of 150 m lies a divide between two more valleys, and lastly to the west of Alexandra Land (Zemlya Aleksandry) and Georga Land (Zemlya Georga) lies the Franz-Vikotoriya Trench whose depth exceeds 400 m. The trench is separated from the valley lying between the Belyj (Kvitøya) and Viktoriya (ostrov Viktoriya) islands by an underwater ridge (100 m deep).

The northern slope of the Archipelago of Franz Josef Land is intersected by trenches running in the direction of the main straits that are associated with the system of north-south fractures. Thus the area of the Polar Basin Slope can be characterized as a region that has been submerged not so long ago in geological time and that has preserved to a high degree

the features of above water (land) relief. Such a bottom relief character accounts for the complexity of the hydrological and hydrodynamical regime, whereby the north strike of the valley serves as a route for the Atlantic waters that penetrate the Barents Sea, circumventing Spitsbergen from the north. But this occurs only in the straits and valleys whose thresholds lie at a relatively great depth. In isolated areas of the valleys depressions and stagnant halistatic areas further the accumulation and duration of ice (M. V. Klenova, 1932). On the other hand, the Atlantic waters penetrating from the north cause an intensified thawing of shore ice and icebergs, which enriches sediments with clastic material: shingle, crushed stone and gravel, so that sometimes, especially on the ridges of underwater slopes of coastal areas, they form the predominant mass of /178
sediments.[1] The composition of shingle and gravel lying on the spurs in shoaling water is diverse: to the northwest of the Vide Fjord (Wijdefjorden; St. 2835) one can find smoothened shingle of gray quartz, gravel which contains grains of smooth basalt, dark sandstone, rosy-colored quartz, (and) talcose schist. On the underwater extension of Northeast Land (Nordaustlandet; St. 2166, 183 m; St. 2167, 102 m) broken granite has been found consisting of medium-size grains, a similar type of gneiss, muscovite granite, orthoclase granite-porphyry, micaceous phyllite schist, pinkish-gray dolomite, but farther from the coast (at St. 2836, 139 m), light-gray quartzite, dolerite, pinkish-gray limestone consisting of small

[1]The data obtained during the following cruises of survey ship Persei (Persey) were used: 40th in 1932 by V. P. Zenkovich and E. K. Kopylova; 45th in 1933, 50th in 1934 by T. I. Gorshkova; during the following cruises of survey ship Knipovich: 16th in 1930, by A. D. Dobrovol'skii; 24th in 1931 by K. A. Rachkovska; 32nd in 1932 by M. V. Klenova, and during a cruise of survey ship Sadko in 1935 by M. M. Ermolaev.

crystals, the same phyllitic micaceous schist, light-pinkish and luminous quartzite, arkose with rosy-colored feldspar and smoothened quartz, fine-grained basalt, gabbro-diabase, and in core samples also white limestone. Those are the rocks of Northeast Land (Nordaustlandet) which are found as alluvial deposits, not being covered by the contemporary sediments.[1] To the northeast of Les Sept Iles (Sjuøyane; St. 2842) a shingle of gray sandstone was found, but gray granite near the islands (St. C42). The sandy mud on the slope of White Island (ostrov Belyj or Kvitøya) contains gravel and shingle formed of rosy-colored granite, basalt and flint (St. K500). On the western slope of Franz-Viktoriya Trench (St. 122/19) a core whose upper layer contained 84% gravel and shingle included the white limestone. From an interlayer in the shoal lying to the northwest of Franz Josef Land (St. K489) a bottom corer brought up light-gray sandstone, veiny quartz, flint, but from the areas lying to the north of Alexandra Land (Zemlya Aleksandry) and Georga Land (Zemlya Georga; St. K789 and K790), shingle of white limestone and gray sandstone. The cores obtained from an area to the northeast of Franz Josef Land (St. K794 and K797) contained gravel of flinty rock, basalt, (and) gray schist.

Local differences in the composition of coarse-grained material attest to the absence of transport for long distances, supporting a proposition concerning its accumulation as a result of underwater erosion (from steep slopes. Tr.). Despite the exclusive abundance of coarse-grained material, the sediment distribution is subject to the rules mentioned above. Pink

[1] Bottom grab brought up a multitude of broken rock at all of the stations.

sand is found on a shallow ledge between two trenches at the edge of the Continental Shelf (St. C54, 184 m). In addition to fragmental material, it contains numerous carbonate remains and calcareous foraminifera brought by the Atlantic Current. Muddy sand covers the shoals between trenches and their slopes. To the west it contains a great amount of carbonate fragments and has a dark-gray color with a greenish hue which farther to the east becomes yellowish-gray and, lastly, pink. In the majority of cases it is well sorted (fig. 78) and its histogram has one apex.

The silt particles consist of quartz. On steep slopes, with the presence of a great quantity of coarse-grained material, the muddy sand is characterized by a graph with two apices (St. K122/19, 185 m). In the vicinity of the muddy sand, farther from the coast and at great depths, one can find sandy mud. Its mechanical composition shows a number of transitions from a well sorted sediment with a maximum of particles ranging from 0.1 to 0.05 mm to poorly sorted sediment with an increase in sand material or particles smaller than 0.01 mm. An increase in the quantity of larger fragments is observed as usual when approaching the coast (M. V. Klenova, 1932, 1948), as for instance, on Sturlismaget Shoal (not identified by other sources. Tr.) to the north of Spitsbergen (St. 2169, 208 m), at the /179 northern coast of Northeast Land (Nordaustlandet; St. 2846, 85 m; fig. 78, 2), on the shoal of Franz Josef Land, to the north of it and elsewhere. At depths to 200 m the sediment is replete with rhizopods, at great depths (at St. 2384, 484 m, for instance) spines of sponges have been found, whereas the shells of foraminifera have not been well

preserved. The sediment covering the northeastern coast of Northeast Land (Nordaustlandet; St. 2846; fig. 78, 2) contains gravel, lumps of clay, barnacles, rhizopods and other calcareous remains characteristic of washed-up moraine material and underwater erosions, as in the case of the material lying near the Barents Island (Barentsøya), which was mentioned earlier.

The sandy mud lying on the shoal of Northeast Land (Nordaustlandet) is presented graphically by two apices (St. 2840, 200 m). The two apices are especially well pronounced in a more fine-grained sandy mud which is widely distributed. Such sediments are found on the slope to the northwest of Northeast Land (Nordaustlandet; St. 2836, 139 m; fig. 78, 3), at the entrance to the Hinlopen Strait (Hinlopenstretet) near the submarine ridge to the west of Franz-Viktoriya Trench (St. K122/16, 289 m), near Jackson Island (ostrov Dzeksona; St. 793, 344 m) and in other places. The sediment found at St. 2836, as in the case of the one found at the entrance to the Hinlopen Strait (Hinlopenstretet), is dust-like in dry condition, has a low specific gravity, which corresponds to its nonuniform structure and is reflected in the two apices of the histogram. Another type of the fine-grained sandy mud with a more or less pronounced single apex in graphical presentation lies on slanting slopes: to the north of the Northeast Land (Nordaustlandet), in the entrance to the Hinlopen Strait (Hinlopenstretet), in the deeps of a trench between the Great (ostrov Bol'shoy) and the White (ostrov Belyy) Islands, on a shoal to the north of Franz Josef Land (St. K788, 264 m), to the northeast of it in

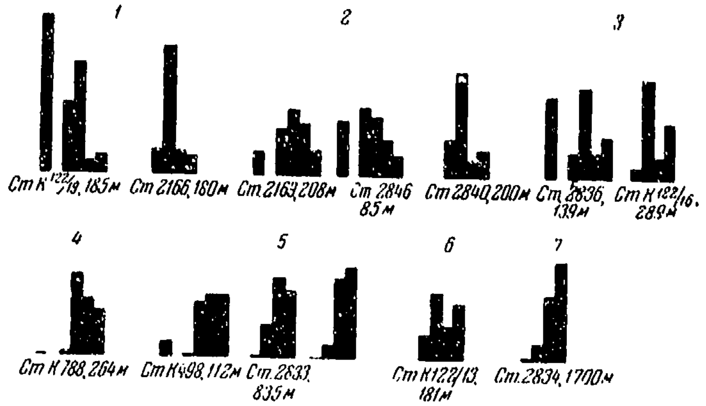

Fig. 78. Types of Mechanical Composition on the Polar Basin Slope.

1--muddy sand (St. K122/19, 185 m; St. 2166, 180 m); 2--sandy mud (St. 2169, 208 m; St. 2846, 85 m; St. 2840, 200 m); 3--sandy mud with particles smaller than 0.01 mm from 20 to 30% (St. 2836, 139 m; St. K122/16, 289 m); 4--the same with a graph having one apex (St. K788, 264 m); 5--mud (St. K498, 112 m; St. 2833, 835 m; St. K792, 520 m); 6--mud whose graph of mechanical composition has two apices (St. K122/13, 181 m); 7--clayey mud (St. 2834, 1700 m). (Explanation of symbols in fig. 33).

the strait between Rudolf Island (ostrov Rudol'fa) and the White Land (ostrova Belaya Zemlya), and on the slope at Graham Bell Island (ostrov Greem-Bell) in the northeastern section of the archipelago. The color of the sandy mud, as that of the muddy sand, changes as we go from the west to the east, and at St. K799 it becomes brilliant pink.

Also the mud is characterized by several types of mechanical composition which lie at greater depths and at greater distances from the coast than the sandy mud. Most of them are characterized by a graph with equal apices and insignificant predominance of one type of particles (for instance at St. 2833, 835 m, in the western part of the area; St. K498, 112 m, on the slope of a trench lying to the northeast of Northeast Land (Nordaustlandet); St. K792, 520 m, in the northern portion of proliv (strait) Britanskiy Kanal; fig. 78, 5, and at a number of others). The mud covering the trenches lying to the north of Viktoriya Island (ostrov /180 Viktoriya; St. 122/13, 181 m), to the east of Cape Fligely (Mys Fligeli), (and) to the northeast of Yevaliv Island (ostrov Yeva-liv) can be expressed by a graph with two apices. The Arctic Basin Slope (St. 2834, 1700 m) is represented by a clayey pinkish-gray mud in the upper layer and of light-pinkish color in the lower layer with numerous spots and ocherous inclusions as well as a concretionary interlayer from periodic reactions at the 37 to 44-cm mark in the end of the core.

The core samples taken from areas characterized by an increased hydrodynamic activity, i.e. from the sediments of muddy sand and sandy mud, were not longer than 20 cm, but sometimes, because of a great quantity of stones, samples could be obtained only by bottom grabs. However, even such short cores disclosed in many areas the older underlying layers which frequently were either not covered by Recent sediments or were protected by the coating of Recent glacial alluvial material. Thus under a layer of sand with gravel (St. C54, 184 m) at the edge of the Continental Shelf

is a pinkish-gray clayey mud 6 cm thick, with gravel, shingle and carbonate fragments. To the northwest of Vide Fjord (Wijdefjorden; St. 2835) the underlying greenish-gray sandy mud, whose composition is similar to that of the samples taken from the shoal of the Northeast Land (Nordaustlandet), is covered with a layer of muddy sand whose thickness is only 1 cm. The pinkish-gray and slightly carbonaceous mud, similar to marl, has been found on the submarine ridge extending to the west of Franz-Viktoriya Trench (St. K122/16 and K122/17). A core obtained at St. K122/16 on a steep slope shows traces of landslides of Recent sediments and the accumulation of rocks occurring in situ (fig. 79), which is disclosed in the form of a rough surface between layers. As in the western part, the pinkish-gray clayey mud was found on a spur of a trench descending to great depths of the Arctic Basin (St. K493). Here it contains carbonaceous remains whereas in the upper layer they are not found.

The upper sections of cores taken from a trench lying to the northwest of White Island (ostrov Belyy) and containing pinkish-gray sediments with crimson-colored hue are evidently not Recent deposits (St. K499, 365 m); downward they merge with accumulations of eroded rocks (marl) found in situ (fig. 79, 3). A core taken from the shoal of Franz Josef Land contained a layer of gravel at the 11-cm mark (St. K489, 213 m) but to the north (St. K788, 264 m; St. K789, 189m) the dense and heavy clay-like, bluish-gray mud containing gray sandstone shingle was separated by an ocherous interlayer from the pink sandy mud layer constituting the upper 9 cm of core, including the 4 cm thick ocherous interlayer. The core discloses a stratification caused by the distribution of ferric oxides.

The cores containing fine-grained sediments disclose a gradual variation of the sediments, but not a single core, even as long as 77 cm (St. 2833, 835 m) reaches the underlying layer. However, individual stages of Recent sedimentation are reflected here in the form of oxidized interlayers of brown oxides characterized by periodic reactions at the following centimeter marks of the cores: 5 to 7, 20, 23 to 24 and 36 to 37. At the 36 to 37-cm mark the thickness of the interlayer is 1.5 mm; above it are three alternating rings and three or four diffused rings; below it are a light-pinkish layer 2 cm thick and three alternating rings 0.5 mm wide at a distance of 3 to 4 mm from one another. Thus here, due to slow sedimentation, not less than three or four stages in the formation of oxidized coatings are reflected.

The histograms (table 13) of core samples taken from the slope of the Polar Basin are characterized by bends in the curve of particles ranging from 1 to 0.1 mm, which results from the addition of coarse supplementary material brought, possibly, by the ice (fig. 74, β). Bends in the curves presenting the coarse and fine silt attest to the activity of hydrodynamical regime. As a consequence of great range in the variation of depth, a direct relationship between the depth and the mechanical composition of sediment is usually observed.

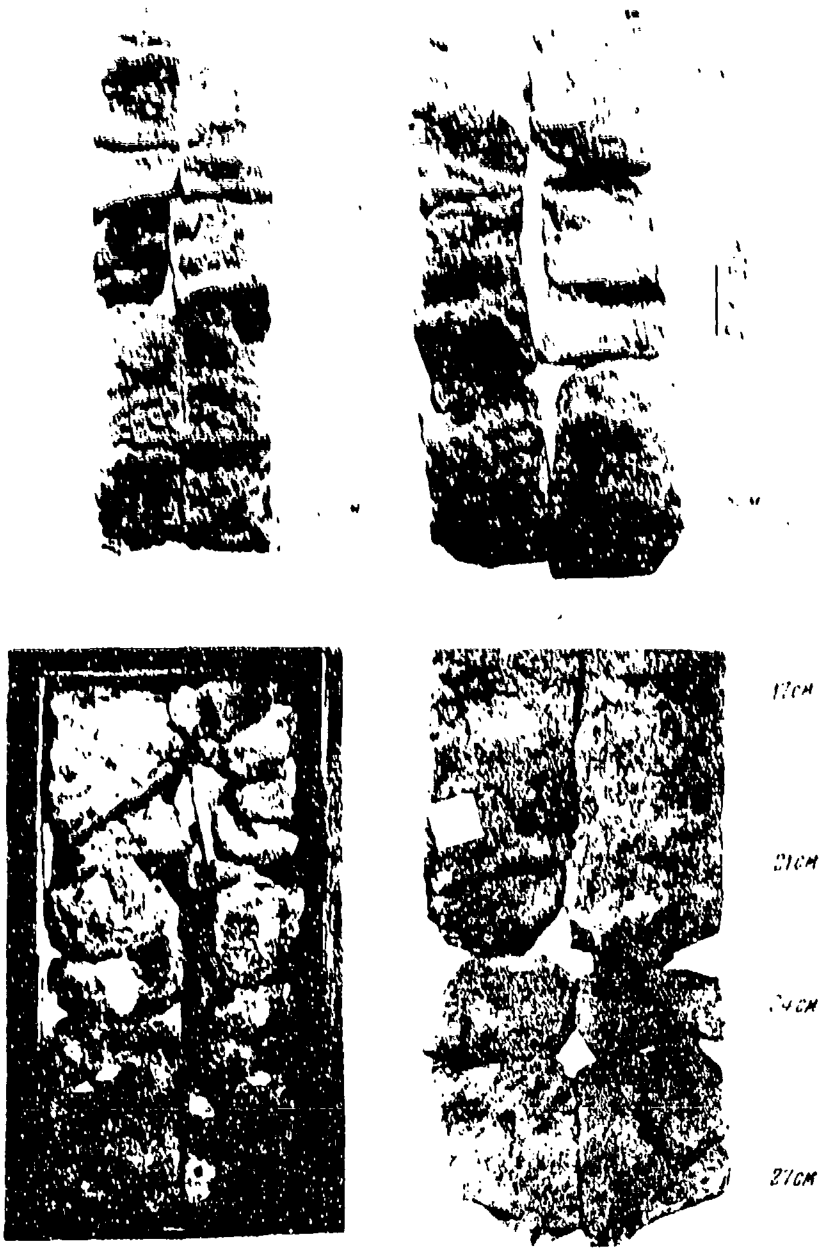

Fig. 79. Core samples taken from underwater slopes of the Polar Basin.

1--core 23 cm long (St. K789, 189 m). At 1 to 9 cm marks sandy mud is observed; at 4 and 11 cm, ocherous interlayers; 2--rough surfaces between layers on the slope of the Polar Basin (St. K122/16, 289 m; at 8 to 28 cm marks of sample cores); 3--core 15 cm long (St. K499, 365 m). Accumulation of glacial alluvial deposits consisting of rosy-colored marl in a valley lying on the northwest of the White Island (ostrov Belyy); 4--core at St. 2833, 835 m; at 17 to 27 cm marks of sample core. Pinkish interlayers at 20 and 24 cm marks of the core.

Table 13

THE MEAN MECHANICAL COMPOSITION OF SEDIMENTS IN THE NORTHERN SECTION OF THE BARENTS SEA.

Bottom type	Fragments <0.01 mm in %	Depth in m		Fragments in mm					Number of Analyses
		from-to	mean	> 1	1-0.1	0.1--0.05	0.05--0.01	<0.01	
The Polar Basin Slope									
Sand	<5	-	184	(8,5)	20,6	55,0	20,9	3,5	1
Muddy Sand	5-10	54-185	137	(25,2)	28,7	50,2	13,3	7,8	5
Sandy Mud	10-20	58-484	175	(7,3)	18,4	42,4	23,9	15,3	14
" "	20-30	57-376	208	(13,4)	9,7	40,4	24,6	25,3	17
Mud	30-40	112-835	283	(2,0)	4,6	30,5	30,6	34,3	11
"	40-50	241-520	380	(0,3)	1,1	21,2	31,9	45,8	2
Clayey Mud	>50	-	1700	Traces	0,6	9,8	35,5	54,1	1
The Northern Plateau									
Sand	<5	94-132	113	(1,0)	67,9	25,7	3,7	2,7	2
Muddy Sand	5-10	75-249	159	(2,2)	24,5	55,8	11,4	8,3	6
Sandy Mud	10-20	47-330	226	(2,9)	9,2	54,5	21,1	15,2	27
" "	20-30	53-362	238	(1,6)	5,5	44,2	25,7	24,6	31
Mud	30-40	138-430	264	(0,3)	2,0	32,2	31,2	34,6	51
"	40-50	113-410	300	(2,7)	1,9	23,5	31,0	43,6	44
Clayey Mud	50-60	230-340	301	(0,2)	2,7	19,8	22,6	54,9	9
" "	>60	-	344	-	1,6	18,5	19,8	60,1	1

17. The Northern Plateau

According to the character of relief, the Northern Plateau occupies an intermediate position between the depressions that constitute the basic sections of sediment accumulations and the elevated sections discussed above. The Northern Plateau occupies the entire northern part of the Barents Sea, predominantly the deep areas divided by elevations, including the littoral zone around islands. The northern boundary of the area is formed by the highest points of submarine valleys between the Great, White and Viktoriya islands (ostrov Bol'shoy, ostrov Belyy, ostrov Viktoriya) as well as by a rather low threshold dividing the northern part of the Franz-Viktoriya Trench from its southern part. The eastern boundary of the plateau runs near Long. 60° E along the western slope of Polar Basin Bay (Bukhta Polyarnogo basseina) and along part of the elevation of the Gorbovy Islands (ostrova Gorbovy or Gorbovyye ostrova); the western boundary extends along the underwater slope of Edge and Barents Islands (Edgeøya and Barentsøya), adjoining the Northeast Land (Nordaustlandet); and the southern boundary touches the northern tip of Western Trench (Vestfjorddalen), the Persey Elevation, the Central and Northeast (Nordaust) Depressions.

For the sake of convenience, let us base the division of the Northern Plateau into areas on the elements of relief (fig. 80). Between the elevations, i.e. the littorals, of King Karl Islands (Kong Karls Land), the Northeast Land (Nordaustlandet) of Spitsbergen, the White and Viktoriya

Islands (ostrov Belyy and ostrov Viktoriya), Franz Josef Land and the submarine bank of Persey, the Northeast (Nordaust) bank or shoal and the Knipovich Shoal (K. banka) lie relatively flat areas with depths reaching 350 to 400 m: the Franz Josef Trench, the Trench of Northeast Land (Nordaustlandet), the Trench of King Karl Islands (Kong Karls Land), (and) a depression of Cape Flora (Mys Flora). All of the areas are characterized by more or less closed troughs whose contours still have to be defined and which serve as locations for the accumulation of sediments with a very stable composition (M. V. Klenova, 1948), predominantly mud which at places merges with clay-like mud.[1]

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[1] The data obtained during the following cruises of survey ship Persei (Persey) were used: 3rd in 1923, 5th in 1924, 17th in 1928, 21st in 1929, 36th in 1931, 50th in 1934, by T. I. Gorshkova; 11th in 1934, by P. N. Novikov; the following cruises of survey ship Knipovich: 16th in 1930, by A. D. Dobroval'skii; 24th in 1931, by K. A. Rachkovskaya; 32nd in 1932, by M. V. Klenova; and during a cruise of survey ship Poliarnik (Polyarnik) in 1953 by N. K. Khanaichenko.

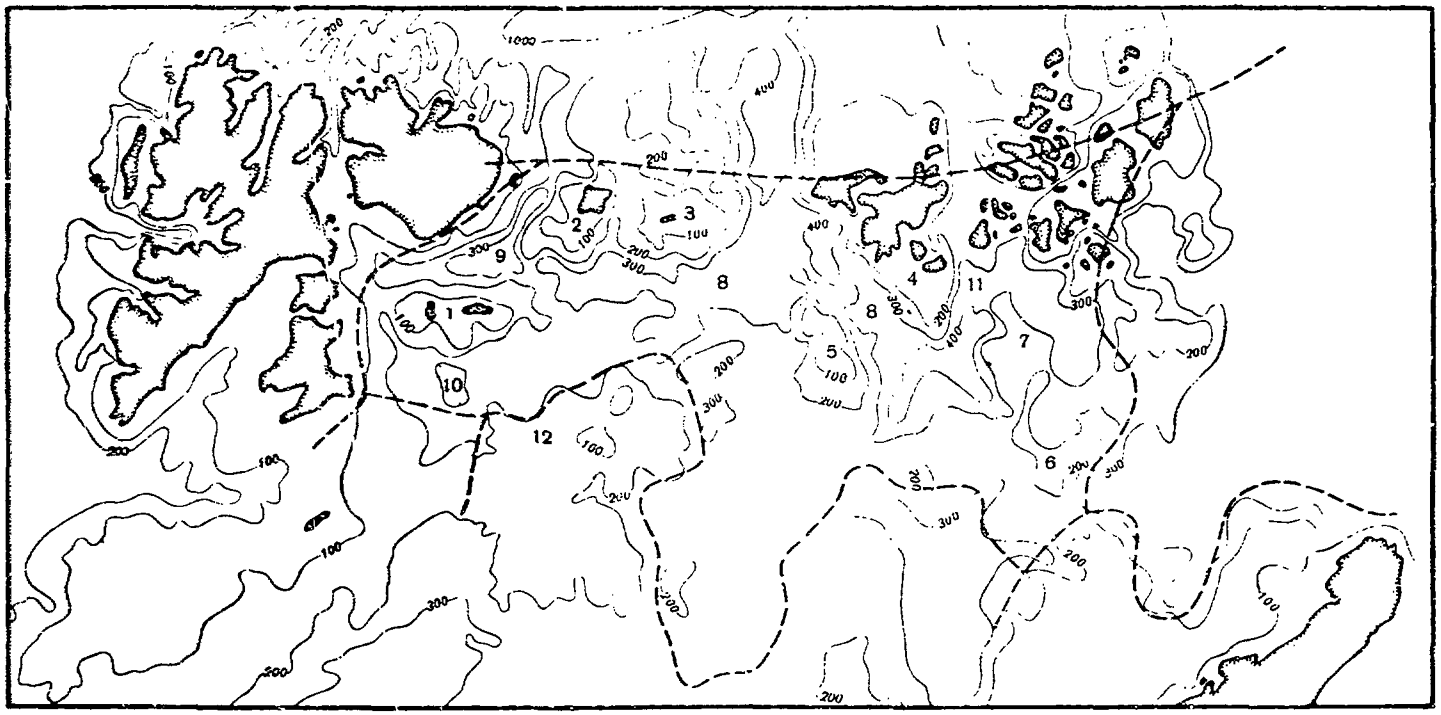

Fig. 80. Bottom Relief of the Northern Plateau (Nord or Severnoye Plateau)

1--the shoal of King Karl Islands (Kong Karls Land); 2--Shoal of White Island (ostrov Belyy); 3--Shoal of Viktoriya Island (ostrov Viktoriya); 4--Shoal of Cape Flora (Mys Flora); 5--Bank of Persey (banka Perseya); 6--Northeast Land (Nordaustlandet); 7--Knipovich Bank (banka Knipovicha); 8--Franz-Viktoriya Trench; 9--Trench of Northeast Land (Nordaustlandet); 10--Trench of King Karl Island (Kong Karls Land); 11--Depression of Cape Flora (Mys Flora); 12--Persey Elevation (Vozbyshernnost' Perseya).

A peculiar hydrological system with an intermediate cold layer and the low temperature of bottom waters, which are enriched by carbonic acid, though containing a sufficient amount of oxygen, lead to the development of a thick oxidized coating. The sediments of the Northern Plateau have a pink color, the thickness of the oxidized layer reaching its maximum for the entire Barents Sea. The slow rate of sedimentation, which is associated with the absence of fine-grained material, furthers the accumulation of sesquioxides and the formation of concretions in the sediments. The presence of drift ice in the area through the major part of the year serves as an agent transporting the coarse fragments, which are subject to a ferrous weathering. Due to the presence of ice, which is frequently found around islands, the shallow coastal areas have been little investigated and the boundaries of distribution of coarse fragments have been demarked only approximately around the islands.

With respect to open sea, one can say that a large quantity of coarse fragments are found on the Persey Bank (banka Perseya) where fragments of calcareous sandstone have been lifted by trawls. Limestones teeming with burrows of mollusks and completely replaced by ferrous oxides have also been found on the slope of the Northeast (Nordaust) Depression. Near the Knipovich Bank (banka Knipovicha), the gravel found in the lower layer of cores (St. 1963) consisted of gray sandstone with a small calcareous admixture. The gravel and gray sandstone shingle are found in sample cores taken from the western portion of the plateau. Shingles of granite have been found in the underlying layer near the Northeast Land

(Nordaustlandet). The broken material found in the lower sections of cores is variegated and in places it covers the glacial alluvial deposits and rocks found in situ.

The color of the sand and muddy sand that covers the bottom on the Persey Elevation (St. 99, 75 m, etc.) is pinkish-gray, becoming gray and sometimes greenish-gray toward the bottom; a similar situation exists on steep slopes, as for instance between Cape Flora (Mys Flora) and Franz-Viktoriya Trench (St. 1965, 132 m - sand; St. 2888, 249 m - muddy sand; St. 1946, 176 m - on the slope of the Polar Basin Bay; fig. 81, and elsewhere). As it usually happens, near the coast the quantity of sand particles increases. Also the upper layer of the coarse-grained sandy mud covering the slopes of underwater elevations and valleys has a pink or pinkish-gray color, a greater or smaller admixture of carbonaceous remains, which are frequently tiny and partly dissolved, and a well pronounced migrational occurrence of sesquioxides. Bands of alternating chemical reactions, brilliant pink ferrous interlayers, ocherous spots and pores coated with brown oxides are typical in the material. In lower layers, the mud assumes a greenish-gray or bluish-gray color. Most frequently the graphical expression of mechanical composition of the coarse-grained sandy mud is characterized by one apex; it contains a little gravel and sand particles (St. 2861, 47m, on the underwater base of King Karl Islands (Kong Karls Land; St. 1972, 262 m, on the slope of Northeast Depression (Nordaust D., or Severo-vostochnaya vpadina; fig. 81, etc). Only the cores obtained to the south of Cape Flora (Mys Flora;

St. 98, 325 m; St. 2693, 224 m) were characterized by graphs having two apices, whereby the sandy mud contained mica, interlayers of gravel and shingle.

A more fine-grained sandy mud is expressed by various types of graphical presentation. The graph corresponding to plateau has one apex (St. 1248, 240 m, near the Persey Elevation, for instance). A less clearly pronounced stratification corresponding to a graph having equal apices is observed in the widened section of the Franz-Viktoriya Trench and on the /185
slopes of Knipovich and Northeast (Nordaust) banks (St. K816, 324 m). A uniform and well assorted sediment, which becomes somewhat more clayey in the lower layers of cores and has a uniform composition, covers the bottom to the south of the Persey Bank or Shoal, on its western and eastern slopes, on a shoal to the north of King Karl Islands (Kong Karls Land; fig. 81). As usual, near the slopes of underwater elevations appear graphical presentations with two apices (examples: St. 2867, 232 m, on the northern slope of the Persey Elevation; St. 101, 250 m, on the slope of the Northeast Bank. Farther to the north between the Northeast Bank and the Knipovich Bank there is a maximum of fine silt in the sandy mud (St. 1963, 260 m; fig. 81).

The next coarser group of mud containing 30 to 40% of particles smaller than 0.01 mm is represented by sediments whose graphical presentation of mechanical composition is characterized by two apices and which are distributed throughout the entire Northern (Nord) Plateau (examples: St. 1246, 193 m, on the northern spur of the Persey Elevation; St. 2889, 310 m,

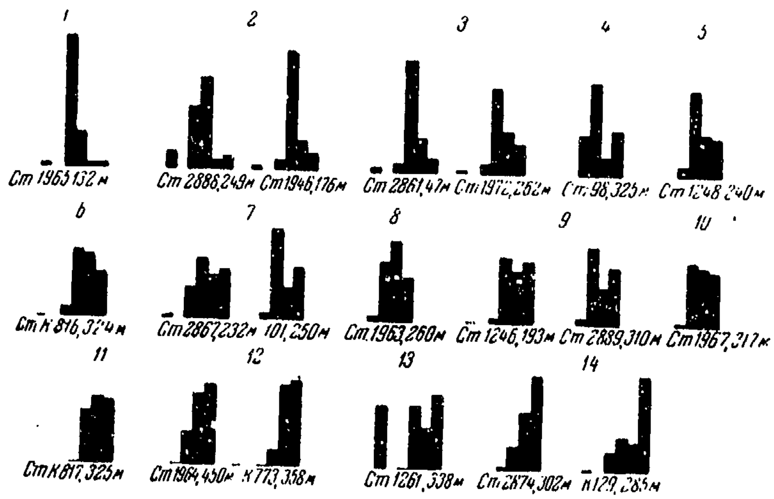

Fig. 81. Types of Mechanical Composition of Sediments on the Northern Plateau.

1--sand (St. 1965, 132 m); 2--muddy sand (St. 2888, 249 m; St. 1946, 176 m); 3--sandy mud with 10 to 20% of particles smaller than 0.01 mm (St. 2861, 47 m; St. 1972, 262 m); 4--sandy mud with two apices in graphical presentation (St. 98, 325 m); 5--sandy mud with 20 to 30% of particles smaller than 0.01 mm, well assorted (St. 1248, 240 m); 6--the same, not so well assorted (St. K816, 324 m); 7--the same, on the slopes of underwater elevations (St. 2867, 232 m; St. 101, 250 m); 8--the same with a maximum of fine silt (St. 1963, 260 m); 9--a more coarse-grained mud with two apices in graphical presentation of mechanical composition (St. 1246, 193 m; St. 2889, 310 m); 10--the same with equal apices in graph (St. 1967, 317 m); 11--the same with a maximum of fine silt (St. K817, 325 m); 12--mud with more than 40% of particles smaller than 0.01 mm (St. 1964, 450 m; St. K773, 358 m; 13--the same, enriched coarse-grained material (St. 1261, 338 m); 14--clay-like mud (St. 2874, 302 m; St. K129, 285 m). Explanation of symbols in fig. 33.

on the slope of the Persey Bank or Shoal (fig. 81 and many others). In the majority of cases such a graph corresponds to the upper layers of cores beneath which lie sediments of a different composition. In some samples the non-uniform composition — an admixture of coarse grains — can be distinguished visually. Also widely distributed are sediments whose graphical presentation has equal apices (St. 1967, 317 m, in the Franz-Viktoriya Trench) or a poorly expressed maximum of fine silt (St. K817, 325 m, between the Northeast and Knipovich banks where the sandy /186 mud has the same composition; in a valley between the White and Viktoriya islands (ostrov Belyy and ostrov Viktoriya) and in several other places).

Most of the mud samples in which 40 to 50% of the particles are smaller than 0.01 mm and whose graphical presentation has one apex pertain to the accumulation areas where the entire length of cores consists of Recent sediments whose upper layer is pink and lower layer is greenish-gray or light-gray. Such sediments have been found at great depths (St. 1964, 450 m, in an isolated depression to the southeast of Cape Flora (Mys Flora); St. K773, 358 m, on the western spur of Franz-Viktoriya Trench - fig. 81 - and in other places). The sediments whose graphical expressions have two apices have been enriched with coarse-grained material (St. 1267, 338 m, for instance).

Clay-like mud, which is little distributed in the Barents Sea (M. V. Klenova, 1940), is found in isolated depressions of the Northern Plateau (Nord or Severnoye Plateau): in the depression of the Northeast Land (Nordaustlandet), in the extension of the trench of the King Karl Islands

(Kong Karls Land; St. K129, 285 m), in the wide part and in the eastern extension of the extreme western spur of Franz-Viktoriya Trench (St. 2674, 302 m). The respective core samples are represented throughout either by a uniform sediment or a more coarse-grained material is observed in their lower parts (St. K124, 344 m, etc.).

Thus on the Northern Plateau, as in other areas, the sediments whose mechanical composition is characterized by a graph with two apices are restricted predominantly to underwater slopes, but, in contrast to more southern areas, they are found at greater depths, e.g. near the 300-m isobath (fig. 82). The curves with two apices representing the upper layer of sediments in the shallow areas described before corresponded to cores with a thin upper layer and with eroded strata. A thin upper layer has been observed not only on positive relief elements but also in depressions of the Northern Plateau, in particular, in the Franz-Viktoriya Trench and in its branches; not often, however, does the two-layer structure reflect the type of mechanical composition in the upper layer.

On positive relief elements the composition of underlying layers is more diverse than in depressions, and the transition between the layers bears mostly a character of interruption in sedimentation in the form of a mixed layer, (and) interlayers of sand or gravel. In flat areas of depressions the transition is gradual. Thus in the western portion of the Northern Plateau, a dense and heavy pinkish-gray and less saline sediment was observed under a layer 5 cm thick near the entrance to Hinlopen Strait (Hinlopenstretet) (St. 2859, 198 m) and down the slope (St. K122/10,

330 m) at the 20-cm mark of the core. At a lesser depth the core samples contain much gravel and shingle replaced at the 19-cm mark by gray sandy mud, but at the 50-cm mark by light-gray clay-like mud. A pinkish-gray, dense, viscous and slightly carbonaceous clay was found on a slope at the base of King Karl Islands (Kong Karls Land). It is covered by a transitional layer in the form of seams of a more sandy material and ocherous components (St. 2183, 288 m) or in the form of interlayers of clay and sand 0.5 to 1 mm thick, which can be noticed in the bulging section of a dry core (St. 2184, 248 m). On the surface of a pinkish-gray clay one can observe an old weathered layer. It is possible that the entire clay represents glacial alluvial deposits. Between the base of King Karl Island (Kong Karls Land) and the Persey Elevation one can find a dense pinkish-gray mud under a gray sandy mud (between the 7 to 27-cm marks of cores) at a depth of 28 cm from the surface of the bottom (St. 2864, 236 m). At greater depths (St. M111, 273 m) the lowermost layer is dense, heavy, dark-gray with a dark greenish-gray (olive-colored) upper layer, but above it, in a gray sandy mud the ammonite Cadoceras sp. or Macrocephalites sp. of the Callovian stage[1] was found, which confirms the fact that the sediment has originated from rocks occurring in situ (fig. 83).

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[1] I take the opportunity to express my gratitude to B. I. Bodylevskii for his polite identification. — M. K.

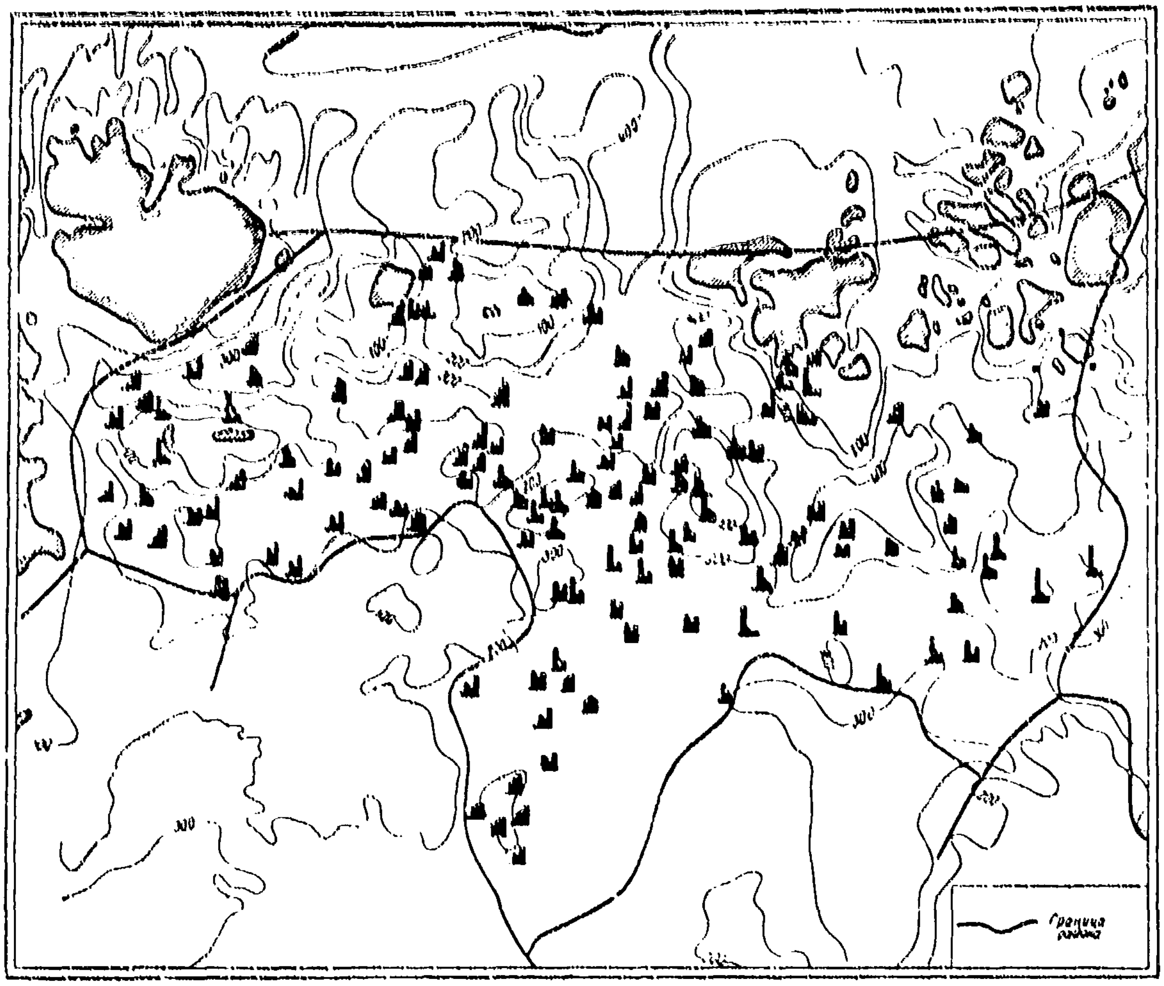


Fig. 82. Distribution of the types of mechanical composition of sediments on the Northern Plateau. (Explanation of symbols in fig. 33).

At the base of the island's littoral zone and to the north of the Persey Elevation the Recent sediment is underlain by a bluish-gray dense mud or clayey mud.

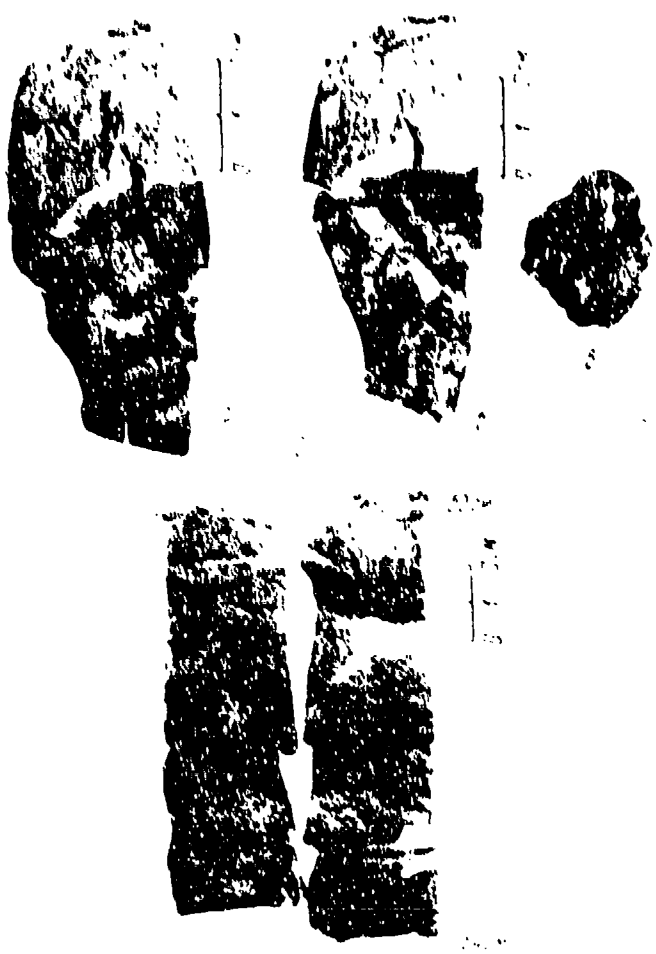
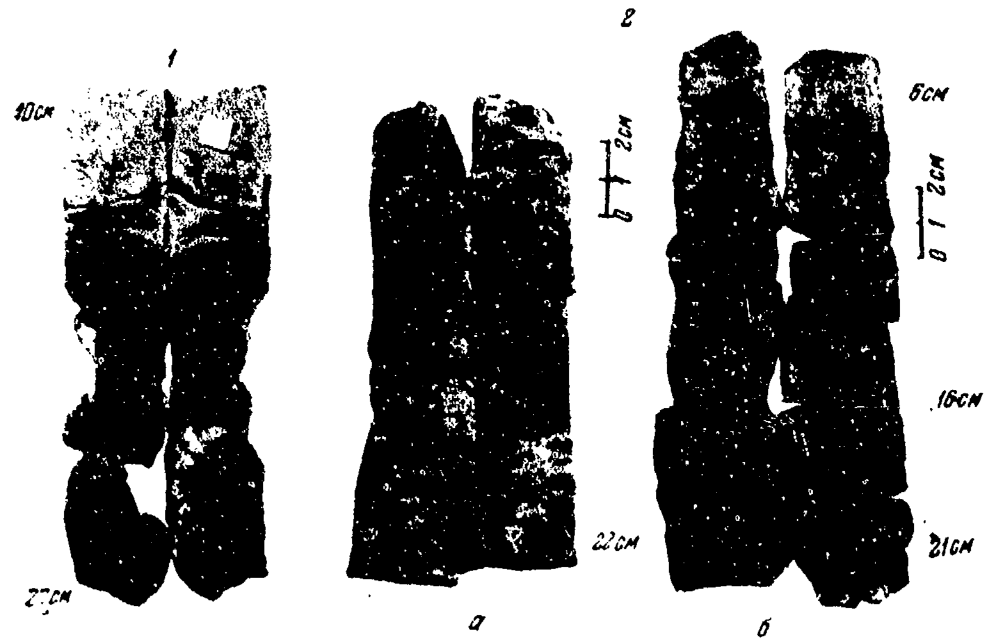


Fig. 83. Cores of the western portion of the Northern Plateau (Severnoye Plato).

1--diluvium of rocks occurring in situ with ammonite (St. Mill, 273 m) between the elevation of King Karl Islands (Kong Karls Land) and the Persey Elevation; a--at 19 to 27-cm marks of core; б--traces of ammonite, gravel, carbonate remains; в--ammonite Cadoceras sp; 2--pink interlayer in clayey mud at 57 to 58-cm marks of core (St. 2868, 244 m), the northern slope of Persey Elevation.

To the south of the White Island (ostrov Belyy), a dense pinkish-gray layer replete with fragments of rosy-colored limestone, similar to the one found on the beaches of the Viktoriya Island (ostrov Viktoriya; M. V. Klenova, 1936), has been observed at the 12-cm mark of sample cores (St. 122/11, 215 m), but to the north in the same trench (St. K501, 228 m) at the 17-cm mark. On a plateau between the Persey Elevation and White Island (ostrov Belyy), the lower sections of cores at 4, 17 and 20-cm marks (St. K771, 22 m; St. K772, 285 m; St. K775, 249 m) contain pinkish-gray clayey mud which is sometimes underlain by a denser gray or bluish gray mud. Here the variation in the composition of sediments does not reflect interruption in sedimentation but a change in conditions. /189
The underlying layer is sometimes slightly carbonaceous, it effervesces when treated with acids. In the southern portion of the cross section P. S. Vinogradova (1946) found a non-carbonaceous underlying layer.

The lower section (from 41 to 52-cm marks) of a core 52 cm long taken at the base of northwest slope of Persey Elevation (St. M117, 240 m) contained a dense yellowish-gray but weakly cemented silt sandstone, which was stratified, the layers being 5 to 7 mm thick. It was overlain (to 28-cm mark) by a bluish gray sandy clay with gravel and shingle of light-colored arkosic sandstone containing carbonaceous interlayers; at a depth of 28 cm from the surface of bottom the color of sediment is yellowish-gray and it resembles a weathered layer; over it lies a gray sandy clay 6 cm thick with gravel and crushed fragments of limestone, black schist and pieces of coal; then follows the Recent sediment consisting of sandy mud with gravel and sandy rhizopods.



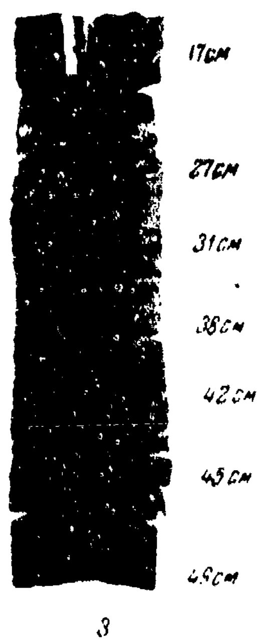
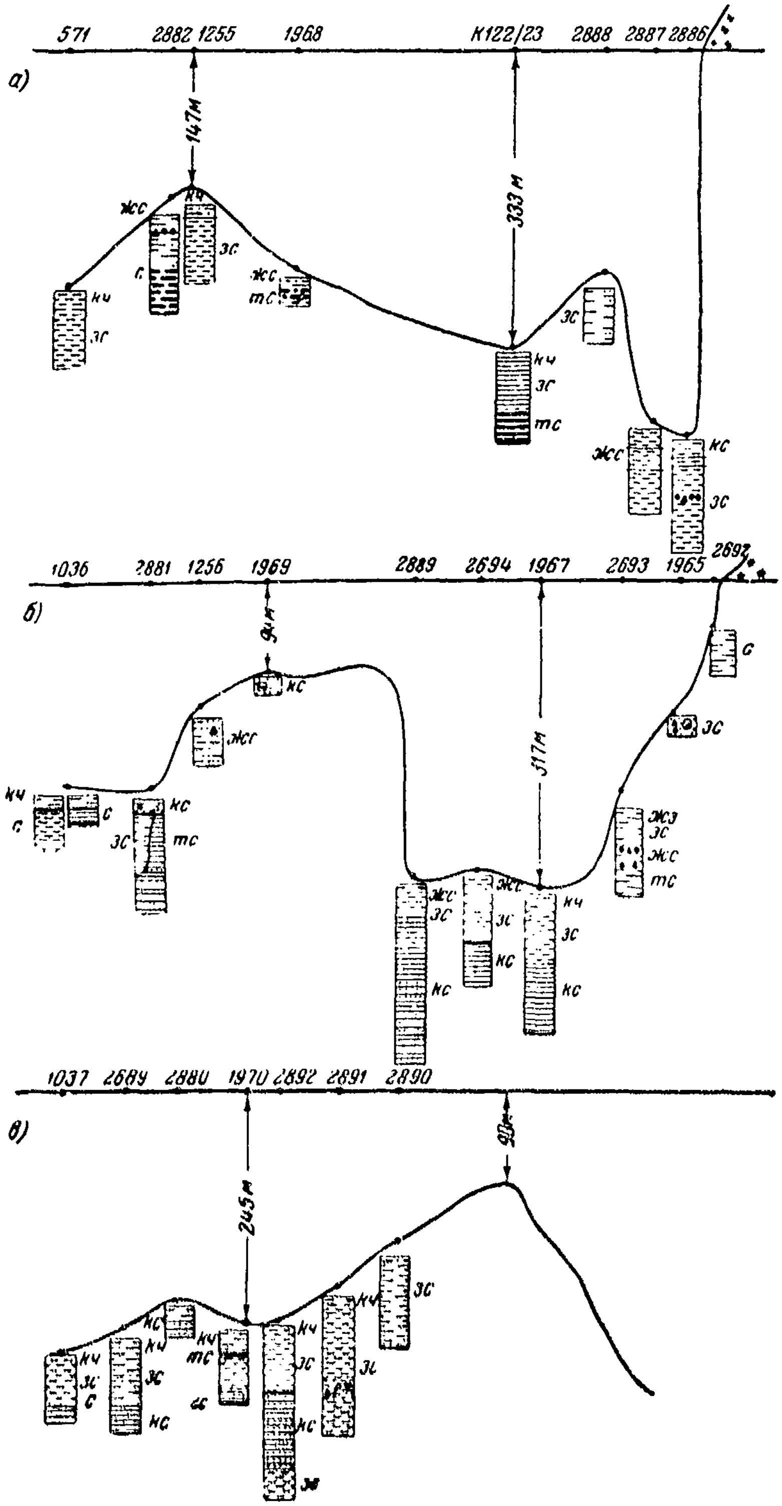


Fig. 84. Stratification of Sediments of the East of the Persey Elevation (Vozvyshennost' Perseya).

1--from 10 to 27-cm mark of core samples at St. 2895, 217 m. Replacement of greenish-gray mud by pinkish-gray mud, beneath by gray mud with shingle; 2--sample cores at St. K514, 225 m; a-- first core, from 9 to 22-cm marks shows replacement of greenish-gray mud with ocherous particles and a yellowish-gray interlayer at the bottom by gray sandy mud; --second core, from 6 to 21-cm marks shows replacement of greenish-gray mud by pinkish-gray mud, with a transitional layer at 14 to 15 cm marks of core; 3--from 17 to 49-cm marks of core at St. 2892, 277 m, at the southern slope of the Persey Bank or Shoal. Replacement of greenish-gray mud by gray clayey mud with sand spots and interlayers.



а)
571 2882 1255 1968 К122/23 2888 2887 2886
147 м
333 м
жс кч зс с тс кс
б)
1036 2881 1256 1969 2889 2694 1967 2693 1965 2692
517 м
кч с зс кс тс жс жсз
в)
1037 2689 2880 1970 2892 2891 2890
245 м
кч зс с кс тс

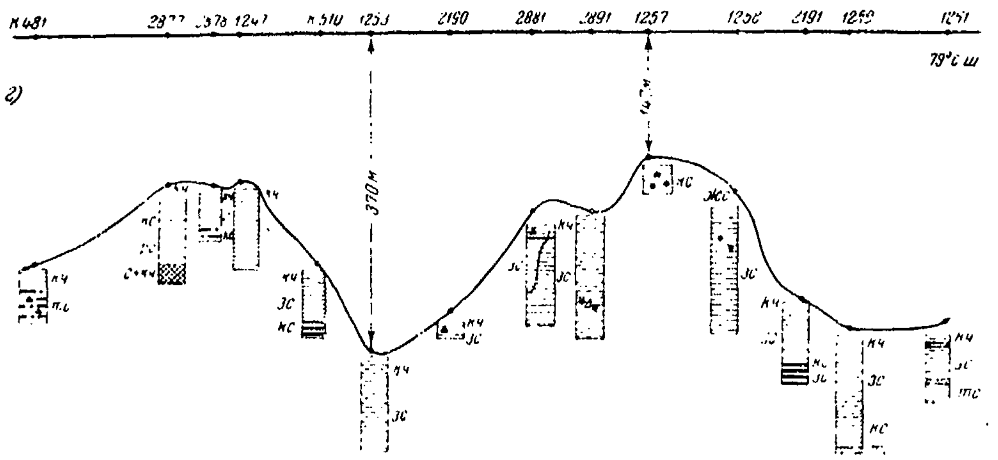


Fig. 85. The Structure of the Persey Bank and Franz-Viktoriya Trench by Profiles.

a--in northeasterly direction from the western slope of the Persey Bank to the Nightingale Sound (proliv Naytingel); б--in the same direction across the Persey Bank to the Norbruk Island (ostrov Norbruk); в--across the southern portion of the Persey Bank; г--across the northern portion of the Persey Elevation, the southern portion of the Persey Bank and the eastern spur of Franz-Viktoriya Trench along lat. 79° E. (Explanation of symbols in fig. 46).

The latter on the surface of the bottom is enriched by pelitic fragments, merging with a pink mud with carbonate remains and sandy and calcareous rhizopods. Ten km farther to the east (St. 2868, 244 m) a core 112 cm long (94 cm in a dry state) disclosed three stages in the sedimentation of pink mud, not counting the Recent layer, at 43 to 44 cm, 57 to 58, and at 77 to 78 cm, pink interlayers were found, which in a dry core can be distinguished in the form of thickenings (fig. 83) as in the case of the Polar Basin Slope.

On the slopes of the Persey Elevation the thickness of the upper layer is variable -- on the northern slopes at the depths of 178, 180, 193, 224, and 240 m it fluctuates from 3 to 5 to 7 cm, but at greater depth from 21 to 23 cm. The contemporary pink-colored sediment is underlain by a dark-gray, sometimes pinkish-gray, nonsaline mud which at places is mixed with shingle of coal or black schist. To the north of the Persey Elevation, (and) in the central section of the Franz-Viktoriya Trench, the thickness of the upper layer lying here on a pinkish-gray or dark-gray clay-like mud decreases from 4 to 13 cm. On the eastern slope of the elevation the thickness of the upper layer at depths of about 200 m fluctuates from 15 to 23 cm; in the lower layer, a dense gray mud is observed; sometimes, however, it forms irregular strata with bends, which may indicate the presence of landslides on slopes (fig. 84).

The structure of the Persey Bank is complex (fig. 85). On the western slope a dense and heavy pink-colored or pinkish-gray mud is covered by a layer of Recent sandy mud 21 cm thick (St. 2882, 160 m), but to the south (St. 2881, 215 m), a contact of greenish-gray sandy mud and of gray clay-like mud is observed from the 5 to 22-cm marks of the cores (fig. 85, б). Farther down, the sandy mud wedges out, and a uniform, nonsaline gray clay-like mud with individual sand admixtures and interlayers replaces the former. The most interesting feature of the Persey Bank is the stratified sediment found at the depths of 21 to 27 to 37 cm from the /192
(bottom) surface on the eastern and southern slopes. Here one can observe the alternation of layers of gray clay and dust-like sand (silt) consisting

basically of quartz, schist and a few carbonate remains. When dried, the cores become divided into disks along the interlayers of sand. In individual cores the position of interlayers coincides well; for instance, at St. 2889 (210 m) at the base of the eastern slope the interlayers of sand are observed at the 35 to 38, 41, 45, 47, 53, 55, 56, 57, 60, 61 and 68 cm marks of core samples, but at St. 2892 (277 m), which is 45 miles to the south of the slope, at the 27, 31, 38, 42, 43, 45, 53, 56, and 56.5 cm marks of the core samples (fig. 85, δ). Along the edges of the Persey Bank, the stratified sediments are similar to river sediments formed during floods. Evidently, an island had been submerged under the sea surface from where silt and clay deposits periodically originated. Possibly, the interlayers of sand testify to seasonal interruptions in the sedimentation of clay materials when the surface layer became washed out by waves. In general, the gray sandy clay is a product of reworking of material occurring in situ under conditions marked by a decreased salinity in comparison with the Recent sedimentation; it is also found in many cores taken to the east of the Persey Elevation and to the south of the Persey Bank. The sandiness of the clay increases with decrease in depth. The thickness of the upper layer fluctuates from 4 and 5 to 28 cm. To the south of the Persey Bank, where current charts indicate one of the branches (fig. 24), the thickness of the upper layer is only 4 cm (St. 1971, 260 m).

The eastern part of the Northern Plateau (Severnoye Plato) is characterized by transitional layers in the form of ferrous interlayers which often

have undergone a diagenetic transformation and testify to the former stages of sedimentation of pink deposits at which the quantity of organic substances had been insufficient for the restoration of sesquioxides as a result of increase in the rate of accumulation of overlying deposits.

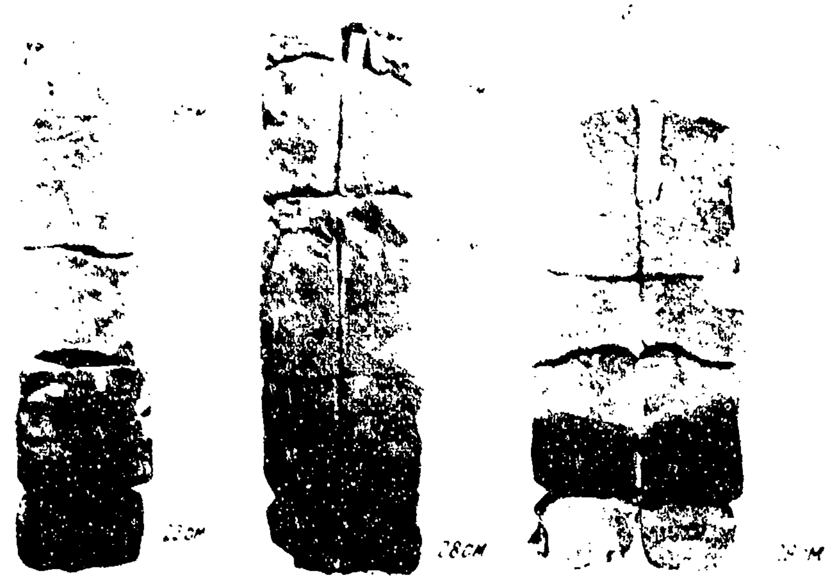


Fig. 86. Bottom structure of the Northern Plateau (Severnoye plato) on the slope of the Northeast (Nordaust or Severo-vostochnoye) Depression and in the Franz-Viktoriya Trench.

1--St. 568, 286 m; from 9 to 23-cm marks of sample cores. Ocherous interlayer at 23-cm mark with gravel of clay lumps; 2--St. 1972, 262 m; from 3 to 28-cm marks of sample cores. Contact between the gray mud and the dense dark-gray mud at 14-cm mark of the core. Slightly sloping surface of contact; 3--St. K508, 362 m; from 15 to 29 cm of the core. Bluish-gray sandy mud with pink interlayer at the 23 to 25-cm marks and the underlying pinkish-gray mud.

Fig. 87. Bottom structure in the eastern section of the Northern Plateau.

1--Northeast Bank: a--St. 1962, 208 m; from the 3 to 10-cm marks of the core sample. Replacement of pink sandy mud by a gray mud; б --St. K819, 201 m; from 6 to 18 cm of core sample. The pink sandy mud lies on a rough surface of dense dark-gray mud; 2--Knipovich Bank: a--St. K815, 296 m; the length of core 30 cm. Interstratification of greenish-gray sandy mud and pinkish-gray mud at the 6 to 9 cm marks, beneath it is a dark-gray mud; б --St. K816, 324 m; from 2 to 14 cm of core. Sandy interlayer at the 9-cm mark and interstratification of greenish-gray and pinkish-gray sediments.

Sometimes, of course, at a very slow rate of sedimentation of the pink layer, the diagenetic process leads to the formation of stable compounds which do not change in a reducing medium when the overlying layer is

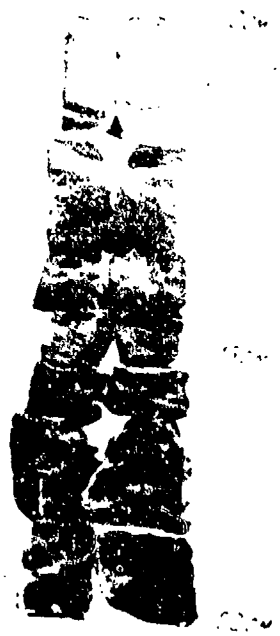


Fig. 88. Bottom structure to the south of the Vil'chek Island (ostrov Vil'cheka; St. K814, 252 m; from 2 to 22 cm of core). Interstratification of greenish-gray and pinkish-gray mud at the 7 to 12-cm marks of cores; interlayer with gravel, rhizopods and carbonate fragments at 12-cm mark of cores; beneath it lies pinkish-gray mud.

being accumulated (fig. 86). Sometimes, the contact between individual layers is not horizontal, which is not a result of the taking of samples /194 by bottom corers because it is usually observed in lower layers, whereas the upper layers lie in a horizontal position (St. 1972, 262 m, to the

west of Northeast (Nordaust) Depression; fig. 86). Also the penetration of the gray or pinkish-gray sediment between the layers of Recent pinkish - or bluish-gray sediments is observed (which is associated with land-slides of sediments down the slopes and is not always detected in the bottom relief due to incomplete investigation; St. K508, 362 m); further, a mixed material of the greenish-gray upper mud and of a dense, gray and little saline clay-like mud (St. 2885, 333 m) is observed. Also the Franz-Viktoriya Trench hides the underlying layer. In the southeastern section of the trench the layer is found at a depth f 37 to 21 cm from the surface of the bottom (St. 1259, 340 m, etc).

The cores taken from the Northeast (Nordaust) Bank (St. 1962, 208 m; fig. 87, 1, a) show that at a depth of 5 to 6 cm from the surface of bottom the pink sandy mud merges with a stratified sediment in which the stratifica n is caused by a difference in the concentration of ferrous oxide; then follows a light-gray clay-like mud. Sometimes the pink mud lies on a rough surface of dense gray mud (St. K819, 201 m, between the spurs of Northeast Bank (fig. 87, 1, б); sometimes interstratification is observed at the line of contact (St. K815, 296 m; St. K816, 324 m; fig. 87, 2, a, б).

Near the lope leading to the Polar Basin Bay one can also observe a complex stratification (St. K814, 252 m; fig. 88); besides, the pinkish-gray nonsaline sediment, which is dense and heavy and effervesces slightly when treated with acids, is overlain by coatings of coarse grained material consisting of rhizopods, carbonate remains, gravel, but more to

the south, on the slope of the Northeast Bank (St. 1946, 176 m) one can observe traces of interruptions caused by weathering.

The mean mechanical composition of sediments of the Northern Plateau (table 13) shows a smooth curve for sand and wave-shaped bends for the coarse silt, which are typical of accumulation areas where new material flows in. The curve of fine silt demonstrates a rise in the interval of mud where 40 to 50% of fragments are smaller than 0.01 mm, which can be explained by a considerable cementation of sediments by sesquioxides (fig. 74).

18. The Western (Bear or Medvezhinskiy) Trench.

The Western (Bear or Medvezhinskiy) Trench occupies the deepest region of the Barents Sea with depths exceeding 450 m and having a mild bottom relief. The boundaries with shoaling areas have been drawn along the 250-m isobath on the slopes of Bear (Medvezhinskaya) Bank in the northwest, on the Persey and Central Elevations and on the Central Plateau in the east and on the area of the Western Commercial Banks (Zapadnyye Promyslovyye banki) in the south. The western boundary coincides with the tentative limit of the Barents Sea along the line Cape Nordkapp-Bear Island (Bjørnøya). Along the boundary with the Bear Island-Hope Island (Medvezhinsko-Nadezhdinskoye or Hopen) Shoals and at places on the eastern slope the bottom relief becomes rather complex and the slope angle steeper. The strait is separated from the Greenland Sea by a threshold about 400 m deep.

The deep, calm areas of the Bear (Medvezhinskiy) Trench are covered by mud which in the eastern section is pink and in the western section greenish-gray with a weakly marked oxidized film in connection with a great quantity of organic substances which is deposited in the area of "the polar front".[1] On slopes the sediments become coarser, turning into sandy mud, seldom into muddy sand. The sandy mud also covers the western part of the trench, /195 which is a deep threshold receiving the main quantity of the Atlantic water; along the slope of the Bear Shoal (Medvezhinskoye melkovod'ye) the outflow of Barents Sea water takes place.

As in other accumulation areas, our core samples represent only the upper layer, not reaching the underlying layer, though the heavy type of bottom corers was used here. On the slope leading to the Greenland Sea and on the slopes of elevations, the thickness of the Recent sediment decreases sharply and the old clay lies on denuded surfaces of bottom or is found in the lower layers of short core samples. The sandy mud and mud has one apex in graphical presentation of mechanical composition if the material is obtained from areas characterized by intense accumulation, i.e. by an increased thickness of the upper layer. The sediment lying on slopes, as well as in areas characterized by active hydrodynamic regime, confined

[1] The data obtained during the following cruises of the survey ship Persei (Persey) were used: 5th in 1924, 7th in 1925, 12th in 1927, 17th in 1928, 21st in 1929, 45th in 1933, 50th in 1934 by T. I. Gorshkova; 19th in 1929 by K. R. Olevinskii; 28th in 1930 by V. P. Zenkovich; 35th in 1931 by L. A. Iastrebova and E. K. Kopylova; 27th in 1931 by M. V. Klenova and I. K. Avilov; 40th in 1932 by V. P. Zenkovich and E. K. Kopylova; 49th in 1934 by P. N. Novikov; 54th in 1935 by S. I. Malinin and Kusovleva; and during a cruise of survey ship Sadko in 1935 by M. M. Ermolaeva.

to the most potent branches of currents, is also expressed by two-apex graphs, provided the thickness of the upper layer is small.

When approaching the coast of shoaling areas, an increase in the quantity of fragments ranging from 1 to 0.1 mm and the appearance of coarse broken material is observed.

The uniform bottom relief and sediment composition of the Bear (Medvezhinskiy) Trench arouses interest in examining its structure in individual areas without dependence upon changes in the composition of the upper layer. On the deep threshold of the western part of the trench, which has been studied at numerous cross sections in the direction of Cape Nordkapp-Bear Island (Bjørnøya) and which coincides with the assumed direction of Caledonian folds, the thickness of the upper layer varies. Thus on the boundary of the Western Commercial Banks (St. 2789, 403 m) and farther to the northwest (St. 2150, 428 m) the core samples 111 and 132 cm long showed contemporary sediments throughout their length: greenish-gray sandy mud in the upper part and a rather fine-grained and darker mud assuming a gradually grayer color in the lower part.

At places the cores contained coarse materials enriched with calcareous rhizopods, carbonate fragments, partly semi-dissolved spines of sponges and chitonic remains. Also thin strata of sand were detected along which the core samples break into segments when becoming dry. However, at about 18 km to the northeast of the first station and 8 km to the north of the second station lies a transitional layer which is a mixture of a gray sand

and of a yellowish-gray or greenish-gray mud underlain by dense gray mud. In the first case (St. 1141, 406 m) the thickness of the upper layer - the sandy mud with rhizopoda and gravel consisting of quartz grains and of fragments of black rock - is only 2 cm thick; at 2 to 7 cm lies a transitional layer, at 8 cm an interlayer of gray sand with gravel covering the even surface of the underlying gray, dense mud with gravel and rhizopoda.

Such stratification may attest to periodic washouts of the upper layer because St. 1141 is located on a potent branch of the Nordkapp Current. To the north of it (St. 1880, 459 m) the character of stratification is different: the thickness of the upper layer is 14 cm; the mixed transitional layer with certain portions of gray clay and interlayers found in various directions at 15 to 29-cm marks of the cores had been formed as a result of landslides because new measurements demonstrated that the point 1880 is near an isolated shoal 400 m deep. Farther to the northwest, at the depths of about 500 and 540 m, an irregular interstratification of greenish-gray sandy mud and gray mud verging on clayey mud (St. 2790, 451 m) was found under a layer of sandy mud 5 cm thick; whereby in the core samples the boundary of the sediments runs in almost vertical direction (fig. 89). The gray mud contains grains of gravel, schist and carbonaceous remains and to the end of the core (47 cm) it is interstratified with a greenish-gray and more sandy mud enriched with spines of sponges and tiny carbonaceous remains.

Sometimes it appears that two cores taken from the same depth near each other (1.5 km; St. 2370, 470 m; St. 1143, 470 m) differ as to their

mechanical composition of the upper layer and the stratification. The first sample contained mud consisting of 30.1% of fragments smaller than 0.01 mm and, at the 75-cm mark of a uniform mud becoming more clayey and gray toward the bottom; the second sample (St. 1143) contained 14.5% of fine particles; the sand particles began to increase at the 15 cm mark; the transition to the lower gray layer of mud with a slight pinkish hue was abrupt, but the other sample taken at the station was marked by irregular interstratification. At about 9 km to the north (St. 1881, 475 m) the interstratification begins at the 21-cm mark and ends at the 14-cm mark of the core samples.

Still more complex is the structure of the bottom at the base of the slope of Bear Bank (Medvezhinskaya banka; St. 2371, 499 m) and on the slope itself (St. 1145, 268 m). Here the upper layer is represented by a poorly assorted sandy mud with a great quantity of coarse fragments whose mechanical composition can be expressed by graphs with two apices. Admixtures of smooth and partly smooth gray schist and sandstone shingle, as well as carbonate remains, calcareous and sandy rhizopods, (and) chitins are found throughout the cores. A thin layer of sandy mud having almost the same composition and marked by a one-apex graph (sometimes two-apices) lies farther to the northeast at the base of the Bear-Hopen Bank (Medvezhinsko-Nadezhdinskoye melkovod'ye) (table 14). At great depths the same mud accumulates in the area.

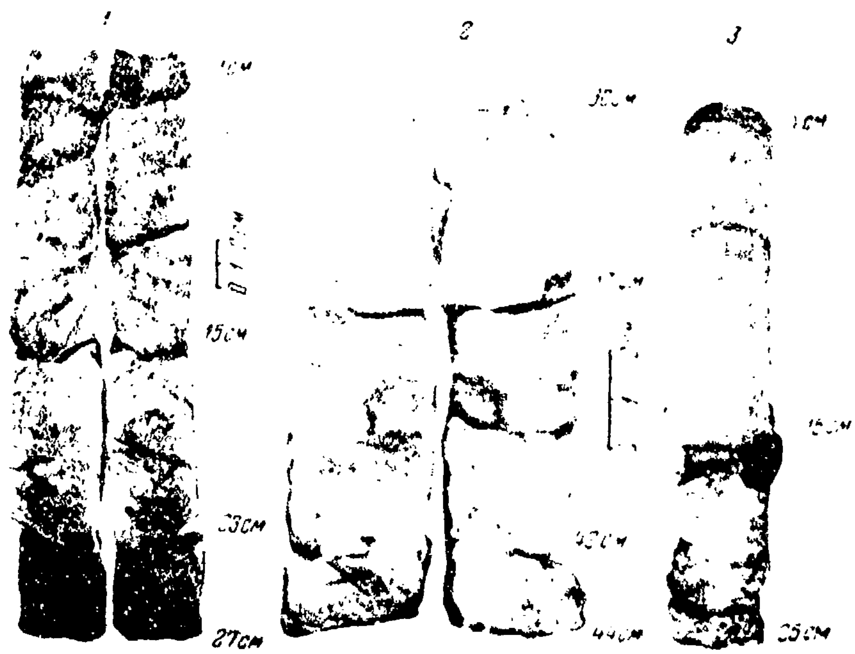


Fig. 89. Stratification of sediments in the western part of the Bear Island (Medvezhinskiy) Trench.

1--cross section Cape Nordkapp-Bear Island (Bjørnøya; St. 2790, 451 m). Irregular interstratification of the greenish-gray sandy mud and gray mud at the 1 to 27-cm marks of the core samples; a sandy stratum having greenish-gray color at the 23-cm mark; 2--St. 1191, 419 m; between the 30 to 44-cm marks of the core is an interlayer of gray mud verging on clay-like mud and lying between the layers of greenish-gray sandy mud; 3--St. 1153, 435 m; between the 1 to 25-cm marks of the core sample is a transition from greenish-gray sandy mud in the upper layer to a denser sandy mud with gravel and shingle; at the 15-cm mark lies shingle of gray schist.

Table 14

THE THICKNESS OF RECENT SEDIMENTS ON THE WESTERN SLOPE OF THE BEAR (MEDVEZHINSKIY) TRENCH FROM SOUTH TO NORTH.

Station No.	Depth in m	Thickness of upper layer in cm	Character of transition	Character of the lower layer
1936b	311	2	Sharp	Bluish-gray clay with a pinkish hue, with grains of gravel.
1936a	280	6	"	The same.
1924	304	11	Gradual. Shingle	Clay-like mud, gray, with a light bluish hue.
654	290	27	Sandy spots. Transition gradual.	Clay-like mud, pinkish-gray.
655	296	5	Shingle, gravel, spines of sponges	Dense mud, rosy-gray with gravel and shingle.
1924e	319	9	Gravel and shingle	Bluish-gray mud with gravel and shingle. Nonsaline.
657	340	11	Clearly marked border	Gray mud with a light pinkish hue, with gravel and shingle.

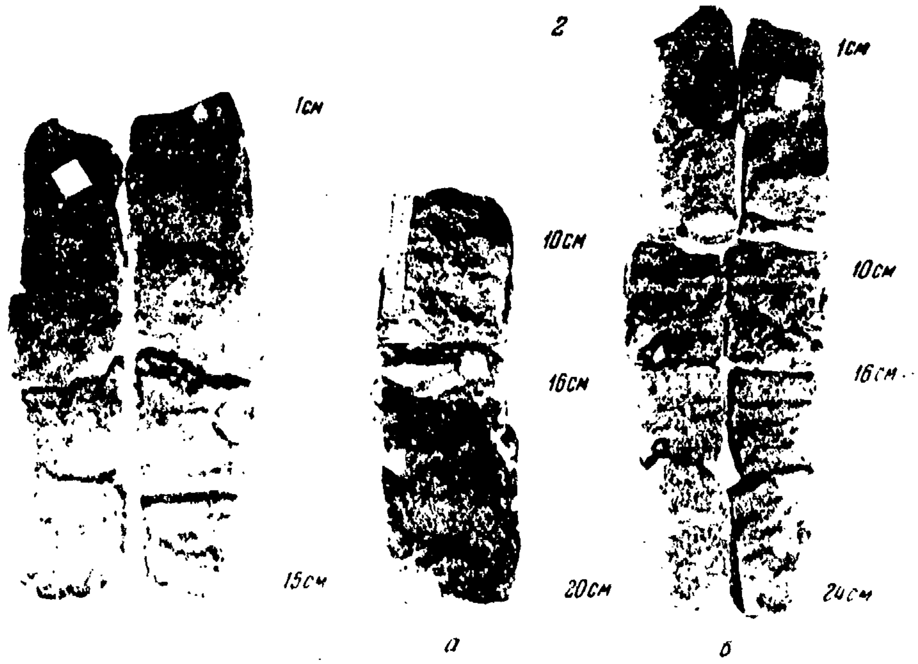


Fig. 90. Structure of the eastern slope of the Bear (Medvezhinskiy) Trench.

1--slope of the Central Elevation, St. 1161, 303 m; core 15 cm long. At the 6 to 9-cm marks worm burrows with ocherous rings are seen in the greenish-gray sandy mud; but at the 10 to 15-cm marks gray clay-like mud; 2--greenish-gray sandy mud on a pinkish-gray "clay" with gravel in the northern portion of the Bear (Medvezhinskiy) Trench; a--St. 1018, 292 m; at the 10 to 20-cm marks of the cores. At the 16-cm marks the surface of the lower layer is rough; б--St. 1170, 311 m; length of core is 24 cm. At the 16-cm mark is a sandy stratum border between the upper and lower layers.

At several stations (St. 2009, 300 m; St. 1923, 267 m, for instance) very short cores (4 to 25 cm) of Recent sandy mud or of mud whose graphical presentation of mechanical composition has two apices were obtained, with a great quantity of gravel and shingle originating from local rocks, e.g. of the pink sandstone with coal strata, (and) of the weathered and fresh gray schist.

Despite the small length of cores taken from the eastern slope of the Bear (Medvezhinskiy) Trench near the Central Elevation, the Central Plateau and the Western Commercial Banks a gray clay-like mud of low salinity was observed under sandy mud (at St. 1161, 303 m, for instance; fig. 90).

On the spur of the Central Elevation (St. 1235, 325 m) a sediment of light chestnut color was found, which is associated with the type of rocks occurring in situ and their weathering product, as was pointed out above. In the submarine gulf between the Central and Persey Elevations (St. 1549, 298 m) sandy mud was found with an increased quantity of fine silt, which was pointed out in connection with the sediments enriched with organic substances.

In the northern part of the Western Trench, nearer to the Bear Shoal (Medvezhinskoye melkovod'ye), a mixed transitional material was disclosed under a sandy mud and mud whose graphical presentations of mechanical composition have two apices (5 to 10 cm thick); the latter was underlain by a pinkish-gray clay-like mud with grains of gravel, carbonate remains, /199

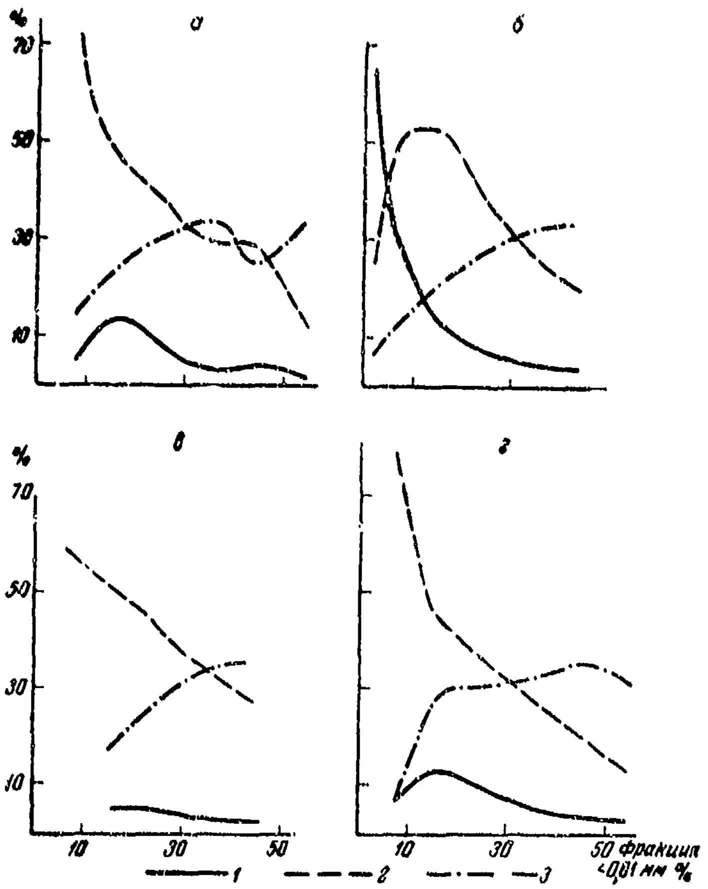


Fig. 91. The mean mechanical composition of sediments in the deep areas of the Barents Sea.

a -- 18th area — the Western Trench; б -- 19th area — the Central Depression; в -- 20th area — the Northeast Depression; г -- 21st area — the Polar Basin Bay: 1 -- fragments ranging from 1 to 0.1 mm; 2 -- from 0.1 to 0.05 mm; 3 -- from 0.05 to 0.01 mm.

Key. Two lines in lower right-hand corner:

Fragments
<0.01 mm,%

gray sandstone shingle and gravel of black schist. A little farther from the slope the thickness of the upper layer increases to 16 cm and the sandy mud characterized by a one-apex graph lies directly on the gray clay-like mud with gravel and shingle (St. 1018, 292 m; St. 1170, 311 m; fig. 90).

The deepest central part of the Western Trench is covered by an extremely uniform mud containing 40% of fragments smaller than 0.01 mm, which is replaced by mud verging on the sandy mud and by sandy mud nearer to the slopes and on slanting elevations in the narrowest section of the trench. Here also the stratification becomes complex and in the lower sections of cores one can observe the underlying layer (St. 1191, 419 m; St. 1153, 435 m, etc.; fig. 89). This is typical of the core samples found in the area crossed by the stronger branches of the Nordkapp Current and the Bear Island (Bjørnøya) Current.

The graphical presentation of mechanical composition (table 15) demonstrates a higher curvature for sand particles in the interval of sandy mud (attributive to stations of the slope of Bear Shoals - i.e. Medvezhinskoye melkovod'ye), a slight increase in the size of fragments in the interval of mud containing 40 to 50% of particles smaller than 0.01 mm, and an increase of the fine silt, which is associated with the cementation of certain samples with organic substances (fig. 91). The increase in the size of particles in the mud interval, which of course pertains to the underlying layer having 10.6% of fragments ranging from 1 to 0.1 mm, occurred in a sample taken by a trawl at St. 224.

Table 15

THE MEAN MECHANICAL COMPOSITION OF SEDIMENTS IN THE DEEP AREAS OF THE BARENTS SEA

Bottom Type	Fragments <0.01 mm in %	Depth in m		Fragments in mm					Number of Analyses
		from-to	mean	> 1	1-0.1	0.1-0.05	0.05-0.01	<0.01	
The Western (Medvezhinskiy) Trench									
Muddy Sand	5-10	-	420	(0,5)	4,2	73,3	14,1	8,4	1
Sandy Mud	10-20	202-475	343	(8,8)	13,6	47,6	23,4	15,4	26
" "	20-30	220-499	348	(6,0)	7,3	38,4	29,7	24,6	37
Mud	30-40	255-499	360	(1,0)	3,0	29,5	33,4	34,1	16
"	40-50	245-460	367	(0,8)	3,4	28,3	25,0	43,3	6
Clay-like Mud	50-60	382-450	416	Traces	1,1	13,7	32,0	53,2	2
The Central Depression									
Sand	<5	-	266	(2,1)	64,8	25,5	7,0	2,7	1
Muddy Sand	5-10	250-325	293	(2,1)	29,4	50,9	12,8	6,9	9
Sandy Mud	10-20	245-354	292	(0,9)	11,1	51,6	21,2	96,1	17
" "	20-30	225-346	287	(0,9)	7,5	39,1	28,6	24,8	30
Mud	30-40	245-359	301	(0,7)	4,8	27,5	33,0	34,7	47
"	40-50	265-354	319	(0,3)	3,4	20,5	33,4	42,7	11

19. The Central Depression

The vast region of the Central Depression occupies the deepest areas of the eastern portion of the Barents Sea and coincides with the meridional deflection reflecting, as was pointed out above, the old stable structure of the earth's crust. The existence of the Central Depression is, of course, associated with the Hercynian platform whose remnants are preserved on the Bear Island (Bjørnøya) in the form of horizontal rocks of the Upper Paleozoic Era. In connection with such origin, the bottom relief of the Central Depression is smooth, and, therefore, abrupt changes /200
in depth and the composition of sediments are observed only at boundaries of elevations. The tentative borders of the depression run along the 250-m isobath.

The knowledge of the Central Depression is not uniform; up to the present time there are vast areas from which no samples have been taken. The bottom of the depression in the deepest areas is covered by mud.[1] Mud merges with sandy mud on the slopes and bends of the axis of depression that are associated with its intersection with structures of east-west strike, but in areas marked by intense currents, in the southern section

[1] The data of the following cruises of the listed survey ships were used: Persei (Persey) - 3rd in 1923, 5th and 6th in 1924, 12th and 13th in 1927, 17th in 1928, 36th in 1931 by T. I. Gorshkova; 11th in 1926, 29th in 1930, by M. V. Klenova; 27th in 1930 by A. S. Ruchik; 46th in 1933 by V. M. Ratynskii; 49th in 1934 by P. N. Novikov. Knipovich - 24th in 1931 by K. A. Rachkovska; 48th in 1934, by S. I. Malinin; 54th in 1935 by M. N. Khokhlin.

for instance, mud verges with muddy sand and even with sand. The sediments of the Central Depression have a greenish-gray color, sometimes slightly yellowish-gray; they contain many chitinous worm tubes, frequently with ocherous rings, calcareous and sandy rhizopods, (and) ocherous inclusions. According to the character of mechanical composition, the major part of the sandy mud samples is expressed by a one-apex graph with a maximum of coarse silt particles, or less frequently, of fine silt particles; mud samples are expressed by a graph with equal apices or with a maximum of particles smaller than 0.01 mm. Two-apex graphs of sandy mud and mud are found on slopes. A typical characteristic of sediments of the Central Depression is their great water saturation in the eastern section of the depression near the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye; St. 770, 245 m; St. 1602, 207 m). The entire length of sample cores (58 and 95 cm in moist condition) is represented by a comparatively brilliant greenish-gray mud with a yellow iridescence and ocherous inclusions. Due to the great quantity of water, the samples shorten almost by 1/3 of 39 and 68 cm when dried, despite a considerable admixture of sand particles (9 and 10.1%, respectively). It is evident that here in the calm belt at the base of Goose Bank (Gusinaya banka) in the area of "Polar Front" an intense accumulation of organic substances takes place, which causes the appearance of green color and the saturation of sediment with water.

The sediments of the Central Depression are wanting in coarse fragments whose quantity, as that of particles ranging from 1 to 0.1 mm, increases

to a degree near slopes, as well as on flat sills dividing individual depressions. Thus a sample taken by a bottomgrab from a slope of the Central Depression (St. 87, 315 m) contained fine-grained schistic arkose sandstone, which was slightly weathered, as well as diabase fragments overgrown with a ferrous coating 1 cm thick. The samples taken from the eastern part of the depression contained gravel consisting of grains of gray schist, basalt, dark sandstone, but the samples taken at the latitude of Matochkin Shar contained broken pieces of granite (a core sample), clay-like schist, weathered rocks in situ and a porous tufa type of rock, effervescent when treated with acids; sometimes, also fragments of veiny quartz were found in the samples. A sample taken from a slope of the Gusinaya Bank contained gravel with a grain of rosy-colored marl (St. 756); a distance to the north (St. 2485, 330 m) - where the presence of sandy mud leads one to assume the existence of an underwater elevation, which has not been charted because of insufficient investigation - the sandy mud contains sand-size grains of pinkish-gray color, but the muddy sand at the 19 to 22-cm marks of the core samples has a brilliant pinkish-gray color; it effervesces when treated with acids and resembles marl due to its outward form. At the bottom of core it is again replaced by a greenish-gray mud.

These facts enable us to suggest that the pinkish-gray color of the underlying layers of the Barents Sea sediments is associated with diluvium of the brilliant-colored clay-like carbonate rocks which are not being denuded at the present time in the coastal belt. /201

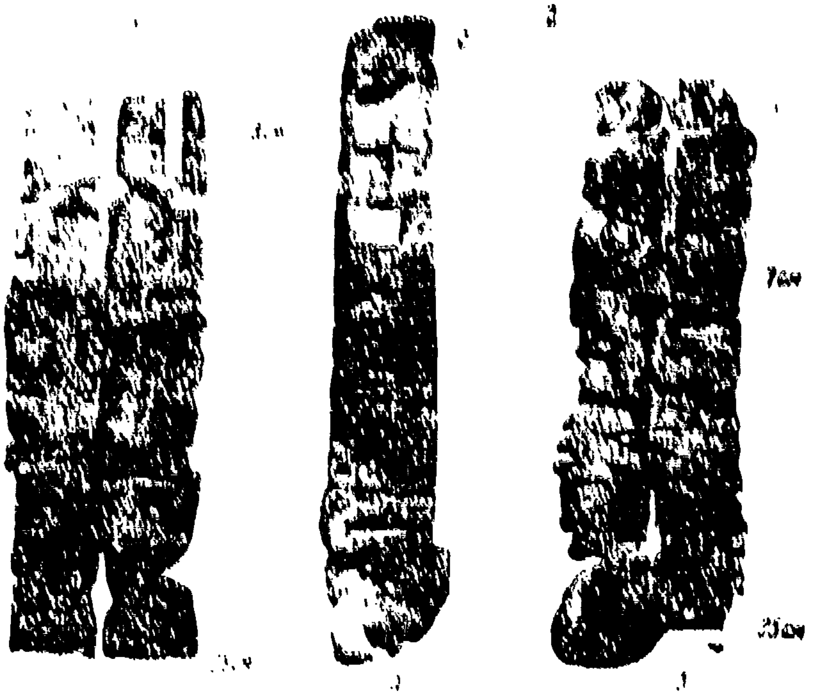


Fig. 92. Structure of the western slope of the Central Depression.

1 -- St. 632, 335 m; at 8 to 29 cm of core. At the 16 to 23-cm mark is a mixture of greenish-gray sandy mud and pinkish-gray mud; 2 -- St. K516, 311 m, near the south-eastern ledge of the Persey Elevation; a -- core 25 cm long; б -- the same core split; replacement of greenish-gray mud at 7-cm mark with a dense and heavy pinkish-gray mud which is stratified.

The layer underlying the Recent sediments is concealed only in the southern section of the Central Depression and on the slopes lying near the Central Elevation, on slopes of the Novaya Zemlya Shoal and of the Central Plateau. On the slopes of the Kanin and Goose Banks (Kaninskaya and Gusinaya banki) in the southern tip, lies a pinkish-gray clay-like mud with a weakly pronounced stratification in the form of thin sandy interlayers not more than 0.5 mm thick, between which one can observe cracks 0.2 to 0.5 mm thick when a dry core is moistened. In fact, this layer lies under sand and muddy sand 3 cm thick (St. 1079, 206 m). A little to the west, the impact of a strong branch of the Nordkapp Current, which turns here against an underwater slope, is manifested in the form of a mixture of sandy mud, verging on muddy sand (St. 253, 260 m), with a gray sandy mud replete with spines of sponges, which are observed at the 35 to 43-cm marks of the core samples. The samples taken from the slope of the Central Plateau disclose the existence of a transitional mixed layer, which is observed at the 16 to 40-cm marks of the core samples (St. 632, 335 m; fig. 92); beneath it lies gray mud with gravel. The upper greenish-gray sandy mud is saline, the pinkish-gray clay-like mud is nonsaline, (and) the gray mud of the lower layer is slightly saline. The same stratification with a transitional layer at the 12 to 19-cm marks of the cores and an interlayer of pinkish-gray little saline mud at the 20 to 22-cm mark was observed on samples taken from a sill between the central and northern deep-water areas (St. 759, 304 m), and from the slope of the Central Elevation (St. 760, 306 m).

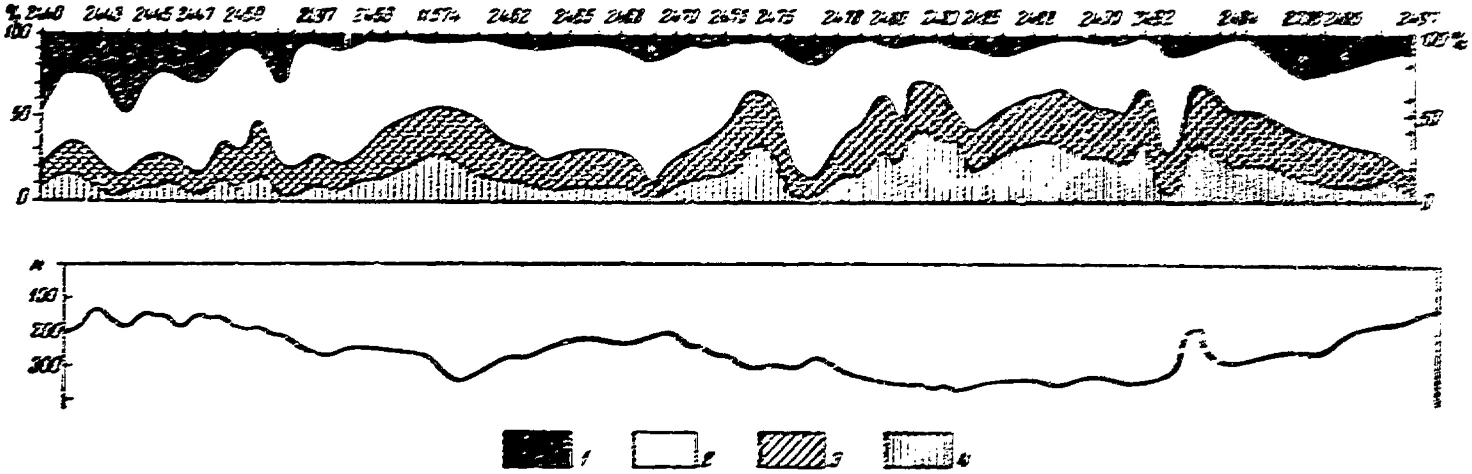


Fig. 93. Changes in the mechanical composition of Recent sediments in the Central Depression

(Symbols are explained in fig. 32).

In the narrowest section of the depression lying between the Central Elevation and the ledge of the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye), the intermediate layer containing much gravel lies at a depth of 9 to 14 cm from the bottom surface (St. 704, 304 m). Farther to the north, near the ledge of the Persey Elevation (St. K516, 311 m; fig. 92) lies a stratified, dense and heavy, pinkish-gray mud[1], under a layer 13 cm thick in one core and under a layer 25 cm thick in the other core.

The profile extending from the southeastern spur of the Persey Elevation to the Gusinaya Zemlya Peninsula (poluostrov G. Z.) intersects various relief elements (fig. 93) and, in line with this, the mechanical composition and stratification of the sediments change. In the northern part of the slope of the Central Elevation (St. 2461, 281 m), at the base of the eastern slope, near the ledge of the northern shoal of Novaya Zemlya (St. 2481, 346 m), the Recent greenish-gray sandy mud is underlain by a pinkish-gray or rosy-gray more fine-grained mud which is replaced at greater depth by gray mud. Traces of submarine landslides, indicated by the irregular interstratification of sediments having various mechanical composition and color, are observed near the eastern slope of the Central Elevation (St. 2473, 281 m), as well as along the eastern edge of the depression (St. 2476, 269 m; St. 2484, 339 m).[2]

[1]Evidently this is the layer that was investigated at St. 91, 279 m (Ia. V. Samoilov and M. V. Klenova, 1927) of which the upper layer has not been preserved.

[2]Insufficient investigation of the relief of the Central Depression does not enable us to present an exhaustive explanation of all characteristics of the bottom structure.

On slopes and in the widenings of the depression the bottom corers did not reach the underlying layer; at places (St. 2482, 350 m, for instance) one can observe a gradual transition between the greenish-gray and more sandy upper layer and the rosy-gray and more clayey lower layer. Sometimes, however, down the core one can notice once again irregular interstratification - a shift in the composition and appearance of material resembling the upper layer (St. 2484, 339 m).

On the whole, despite the great depth, the mechanical composition of sediments of the Central Depression varies in relation to the location of a station with respect to its relief. With a distance from slopes, i.e. with increase in the depth or with widening of a depression, the sediments become more fine-grained and the thickness of the upper layer increases. The sandy mud descends to great depths in areas affected by swift currents, which is true not only of the southern section but also near the ledge of Novaya Zemlya Shoal, for instance, where a branch of the Novaya Zemlya Current (Novozemel'skoye techeniye) passes. St. 764, 304 m; St. 1997, 317 m).

The graph showing the mean mechanical composition (table 15) is marked by a uniform but steeply falling curve for particles ranging from 1 to 0.1 mm and an increase in particles ranging from 0.1 to 0.05 mm in the interval of muddy sand and sandy mud, which is associated with intensified hydrodynamical activity on slopes. In sediments consisting of small grains, the coarse silt decreases uniformly, but the fine increases, as it is typical of areas where accumulation takes place (fig. 91).

In connection with differences in the hydrodynamical regime of the depression, which includes areas characterized by rapid movements of water (the southern, and partly eastern and northern slopes) as well as calm halistic areas, the sediment distribution by depth does not present a clearly marked pattern, as in the case of the Bear (Medvezhinskiy) Trench.

20. The Northeast (Nordaust) Depression

The Northeast (Nordaust) Depression is the northern extension of the Central Depression, separated from it by an elevation whose depth does not exceed 200 m and which, according to the latest measurements of PINRO, we shall call the Northeast (Nordaust) Elevation (Severo-vostochnaya vozvyshennost'). Thus two areas comprise the region of the Northeast (Nordaust) Depression - an elevated and a lowered area. The bottom of the latter is covered by mud which at places verges on clay-like mud; sandy mud lies on the elevated bottom but the isolated depressions on the
elevation are also covered by mud.[1] The upper layer of sediments in the /204
Northeast (Nordaust) Depression has a pink color and contains a small amount of gravel and fine shingle, few carbonate remains and semidissolved shells of rhizopods. Remains with a single-apex graph of mechanical composition are in prevalence.

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[1] The data gathered during the following cruises of the survey ship Persei (Persey) were utilized: 11th in 1926, by M. V. Klenova; 36th in 1931, by T. I. Gorshkova; (and) 49th in 1934, by P. N. Novikov.

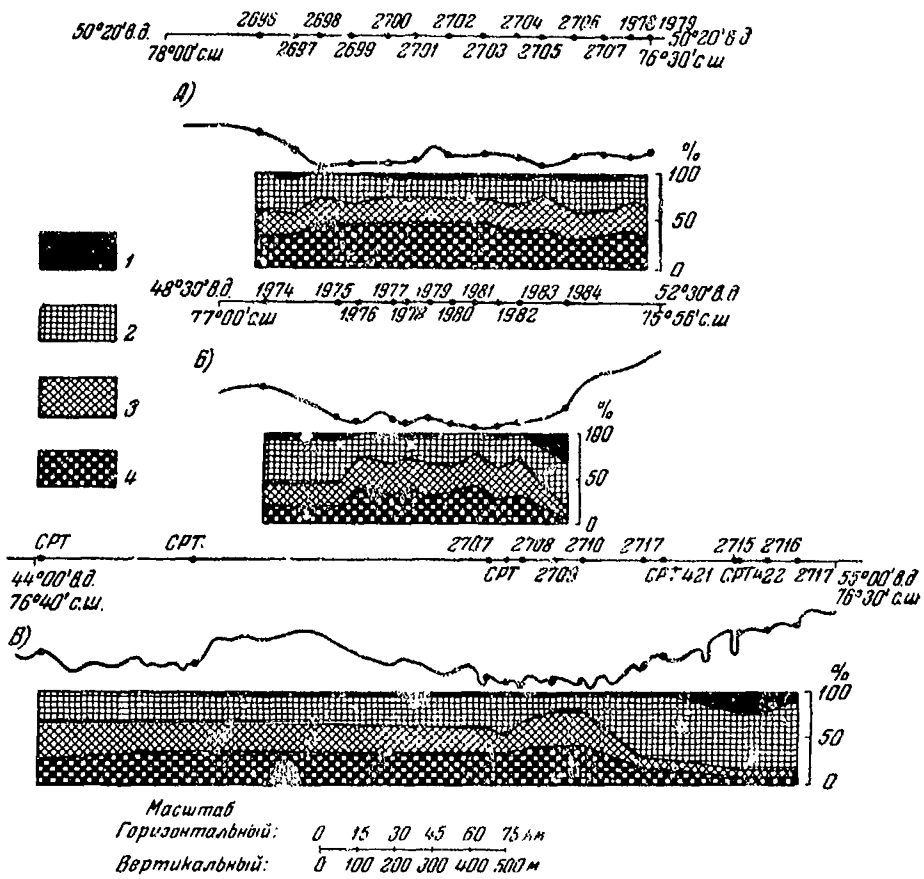

Fig. 94. Changes in the mechanical composition of sediments in the Northeast (Nordaust) Depression.

A -- cross section along Long. 50° E (Stations 2696 to 2707; Б -- cross section from northwest to southeast (Stations 1975 to 1983); B -- latitudinal cross section toward the slope of the Northern Shoal of Novaya Zemlya (severnoye Novozemel'skoye melkovod'ye; Stations 2707 to 2712). (Explanation of symbols in fig. 32).

<u>Key</u>. Three vertical lines in the left center beneath the fig.

Scale
Horizontal: km
Vertical: m

Changes in mechanical composition follow the pattern of the bottom relief. A decrease in depth on the northern and southern slopes (fig. 94), and especially on the eastern and northeastern slopes when approaching the Novaya Zemlya Shoal, decreases the quantity of fragments smaller than 0.01 mm and increases the quantity of sand containing particles ranging from 1 to 0.1 mm. The graphs of mechanical composition assume a weakly pronounced two-apex form. Even minor details in bottom relief are reflected in the changes in range of the size of individual particles. In the southern portion of the depression, the graphs of mechanical composition approach the type having equal apices (at St. 2706, 327 m, for instance).

The pink upper layer of sediments are separated from the bluish - or greenish-gray lower layers, as well as from the contemporary layer, which becomes more clayey toward the bottom, by a sharply pronounced boundary. /205
In the deepest section of the depression (St. 2699 m; St. 2700, 346 m, etc) the cores did not reach the underlying layer, though their length was 36 cm. With a decrease in depth, at Station 2702 (325 m) for instance, a mixed transitional layer is observed in the lower section of core samples at the 30, 31, 43-cm marks; toward the bottom this layer merges with a rosy-gray sandy mud. Nearer to the slopes, the thickness of the upper layer decreases. In the north (St. 2696, 261 m; fig. 95, 1a) one can observe irregular interstratification of the upper and lower layers at the 14-cm marks of core samples and a clearly pronounced stratification in the upper part of the underlying layer; in the southern section (St. 2706,

327 m; fig. 95, 2) a transitional layer exists at the 15-cm mark, and gray clay-like mud at the 20 to 25-cm marks of the core samples; bottomward, the latter layer is replaced by a sandy mud with gravel. In some cores, the transitional layer lying between the Recent and the older sediments is represented by an interlayer of coarse sand and gravel with carbonate fragments. The complex stratification observed on the Northeast (Nordaust) Elevation is probably associated with the phenomena of landslides (St. 1973, 214 m; fig. 95, 3). Here the pink interlayer at the 25 to 27-cm mark of the lower section of the core lies on an uneven surface of gray uniform sandy mud less saline than the upper layer.

Repeated replacement and interstratification of pink and greenish-gray sediments are observed in the southeastern section of the depression (St. 1979, 307 m; fig. 96, 1). At the 29 to 44-cm marks of the core one can observe a gray, slightly sandy mud which is less saturated by water than the overlying layers.

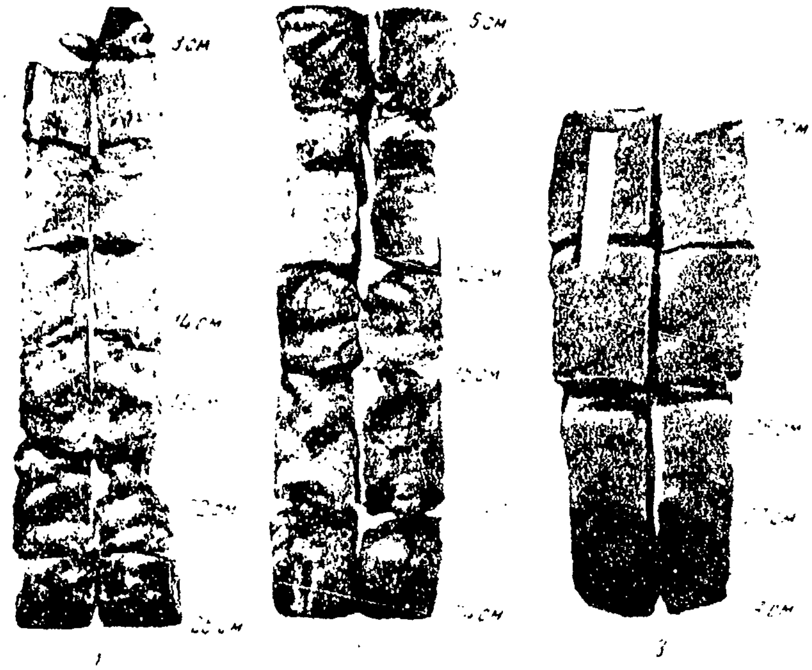

Fig. 95. Stratification of sediments in the Northeast (Nordaust) Depression (in cross section along long. 50° E).

1a -- St. 2696, 261 m; length of core 26 cm. At the 14 to 18-cm marks, interstratification of gray and yellowish-gray mud; at the 22-cm mark, stratification in the upper section of the lower layer consisting of a gray sandy mud; 2 -- St. 2706, 327 m. Transitional layer between greenish-gray and gray clay-like mud at the 15 to 19-cm marks of the core; 3 -- St. 1973, 214 m; at the 17 to 29-cm marks of the core. At the 25 to 27-cm marks of the core is a pink interlayer on an uneven surface of gray sandy mud.

Fig. 96. Bottom structure in the Northeast (Nordaust) Depression near the slope of the Northern Shoal of Novaya Zemlya.

1 -- St. 1979, 307 m; 18 to 36 cm of core. From 24 to 28-cm ocher colored strata. Diameter of core changes. 2 -- St. 1982, 339 m; at 13 to 33-cm. The upper layer consisting of greenish-gray sandy mud lies on a layer consisting of a dark gray sandy mud containing little water. Core thickens. 3 -- St. 2709, 339 m; 11 to 20-cm. The Recent sediment resembling a greenish-gray clay-like mud with worm tubes, pores and gravel.

Table 16

THE MEAN MECHANICAL COMPOSITION OF SEDIMENTS IN THE NORTHEASTERN PART OF THE BARENTS SEA

Bottom Type	Fragments <0.01 mm in %	Depth in m		Fragments in mm					Number of Analyses
		from-to	mean	> 1	1-0.1	0.1--0.05	0.05--0.01	<0.01	
The Northeast (Nordaust) Depression									
Sandy Mud	10-20	210-301	245	(1,2)	4,6	63,0	16,8	15,6	7
" "	20-30	179-339[1]	277	(0,2)	3,8	46,6	26,0	23,6	10
Mud	30-40	218-335	298	(0,1)	2,1	32,6	31,2	34,1	16
"	40-50	312-365	330	(0,3)	0,9	23,3	31,4	44,4	14
The Polar Basin Bay									
Muddy Sand	5-10	-	300	(0,2)	5,8	80,1	6,6	7,5	1
Sandy Mud	10-20	198-459	307	(2,7)	13,2	43,5	27,8	15,5	8
" "	20-30	193-385	269	(1,9)	9,0	35,2	30,0	25,8	11
Mud	30-40	129-419	277	(0,6)	4,2	28,3	32,1	35,4	13
"	40-50	252-513	391	(0,7)	1,9	19,4	35,2	43,5	14
Clay-like Mud	>50	-	352	-	0,2	14,1	32,2	53,5	1

[1] One sample of sandy mud (St. 566) was obtained at a depth of 375 m from a steep slope in an area affected by currents. On a bank a distance of 10 miles, the depth was 190 m.

This part of the core did not decrease in thickness after drying as in the case of the lower layer of the core (St. 1982, 339 m; fig. 96, 2) taken near a slope where the thickness of Recent sediment is 20 cm.

An accumulation of mud marked by a single-apex graph of mechanical composition is found on the eastern slope of the depression near its boundary with the Novaya Zemlya Shoal (St. 2709, 339 m; fig. 96, 3). The sediments of the lower layers of the cores effervesce when treated with HCl. They contain shingles of silicified rocks and probably, cover the accumulations of normal sedimentation for the area.

The mean mechanical composition of sediments covering the Northeast (Nordaust) Depression (table 16) shows regular and gradual changes in the quantity of individual fractions with an increase in the quantity of particles smaller than 0.01 mm (fig. 91), as it is typical of areas where accumulation of sediments takes place. On the average the distribution of sediments by depth is regular.

21. The Polar Basin Bay

The Polar Basin Bay bounding the Barents Sea from the northeast adjoins the system of Central and Northeast (Nordaust) Depressions with its southwestern branch, but in its main north-south direction we can tie it to the trenches lying on the eastern side of Novaya Zemlya in the Kara Sea (Karskoye more). The bottom relief of the Polar Basin Bay has not been sufficiently investigated, but on the basis of the existing data one can discern several submarine valleys adjoining the Northern Shoal of Novaya

Zemlya and the Northeast (Nordaust) Bank. The deep depression at Cape Hope (Mys Zhelania) forms the extreme southern spur of St. Anna Trench. Hydrologically the Polar Basin Bay is tied directly with the latter because, according to observations carried out by survey ships Persei (Persey), Knipovich and Sadko, the presence of Atlantic water has been discovered in the bay.

The sediments of Polar Basin Bay are represented by sandy mud and mud; muddy sand is found on the slope of Northeast (Nordaust) Bank, but clay-like mud lies in a valley on the slope.[1] The color of the upper layer of sediments is pink, turning into pinkish-gray and yellowish-gray at shallower depths and nearer to the coast. The thickness of the oxidized layer reaches 10 to 12 cm and even 23 cm, and also decreases at shallower depths and near the coast. Lower in the core, the oxidized layer is replaced by a greenish-gray layer in the western portion of the area affected by the Atlantic water, and by a bluish-gray layer in the eastern portion of the area. The graphs expressing the mechanical composition are characterized by a single apex, the maximum of coarse silt not being clearly pronounced in the sandy mud interval, as in the case of the maximum of silt particles in the mud interval. Graphs marked by equal apices occur frequently; in a number of trenches the quantity of fine silt increases, which is evidently associated with a cementation of sesquioxides (in the

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[1] The data obtained during the following cruises of the listed survey ships have been utilized. Persei (Persey): 14th cruise in 1927 by M. V. Klenova; 21st in 1929, 36th in 1931 by T. I. Gorshkova; 40th in 1932 by V. P. Zenkovich and E. K. Kopylova; 49th in 1934 by P. A. Novikov; Knipovich: 32nd cruise in 1932 by M. V. Klenova.

Cape Hope Trench (Nya Zhelania Trench; St. 870, 459 m; St. 871, 313 m, and several others). When approaching the slopes, the amount of sand particles and coarse fragments increases (fig. 97); the sorting of sediments is poorer and graphs marked by two apices of mechanical composition seldom occur (St. 2728, 235 m; St. 2194, 290/270 m on the slope of the Novaya Zemlya Shoal; St. K800, 129 m, near Evaliv Island (ostrov Yeva-liv); St. 1266, 290 m and St. 1268, 348 m on the slope of Northeast (Nordaust) Bank; St. K811, 195 m near a bank toward the southeast of Frans Josef Shoal).

The quantity of enclosed pink sediments decreases as the particles become smaller. The clay-like mud does not contain inclusions (St. 1945, 351 m) but is marked by strata in which almost black layers enriched with high-order manganese oxides alternate with pink layers (fig. 98, 1, a). At the 11 to 28-cm marks of the cores, the layers of pink mud alternate with greenish-gray mud, each of which is 0.5 cm thick; lower, at the 29 to 43-cm marks lies a dense greenish-gray mud with yellow spots and calcareous inclusions. It often happens that in the mud, which sometimes turns into clayey mud toward the bottom of core, one can observe ocherous inclusions formed around the worm tubes. They are also preserved in the restored lower layer, which confirms the assumption of partial cementation of the sediment not disturbed by either the active hydrodynamic regime or by the inflow of material from other sources. /208

The sandy mud near the Novaya Zemlya Shoal contains gravel and shingle of weathered schist and gray sandstone, small carbonate fragments and shells

of mollusks (St. 2194, 290/270 m) as in the case of the adjacent shoal. The sandy mud taken from the northwestern slope (St. 1948, 195/250 m) contains an admixture of gravel of black schist and tubes of worms which have also been preserved in the restored bluish-gray lower layer.

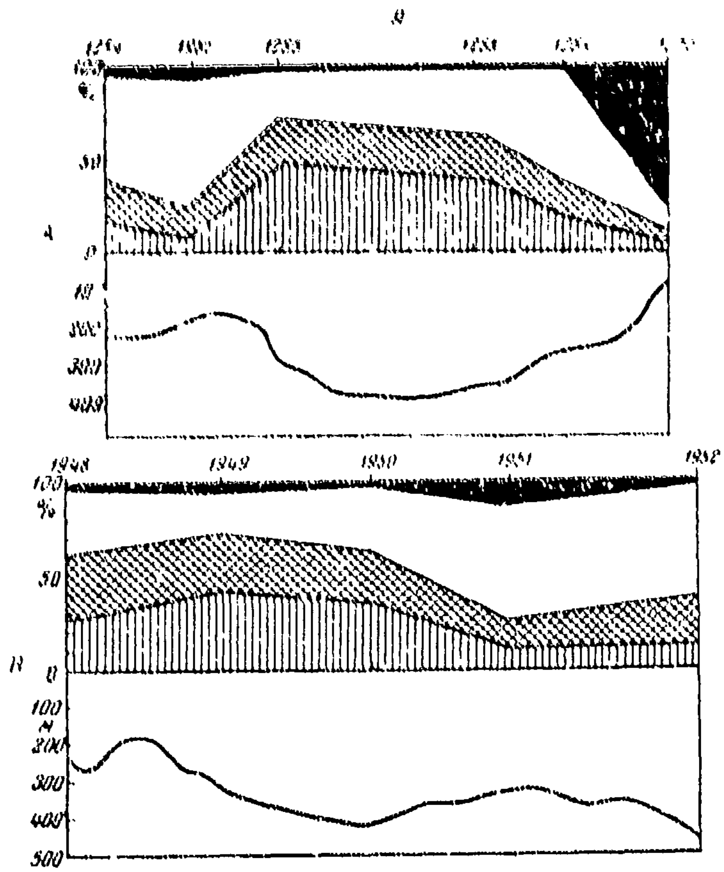

Fig. 97. Changes in mechanical composition in connection with bottom relief in cross sections across the southern portion of the Polar Basin Bay.

A -- from Northeast (Nordaust) Bank toward the ledge of Novaya Zemlya Shoal (Sts. 1266 to 1270); Б -- in the direction of cross section from Cape Flora (Mys Flora) to Cape Hope (Mys Zhelaniya; Sts. 1948 to 1952). (Symbols are explained in fig. 32).

Gravel formed of black rocks has also been observed to the east of Franz Josef Land. The sandy mud on a steep slope near Cape Hope (Mys Zhelaniya) contains much gravel and shingle of gray schist and light-gray sandstone, as well as worm tubes, calcareous rhizopods and tiny carbonate remains. Further to the east, in the northern section of the Kara Sea (Karskoye more) the composition of fragments includes other rocks which evidently have arrived from the Vize (ostrov Vize) and Uyedineniya (ostrov Uyedineniya) Islands (M. V. Klenova, 1927).

Typical features of the sediment stratification in the Polar Basin Bay are the presence of ocherous inclusions, ferrous layers, dense concretionary interlayers and other phenomena marking accumulation and migration of sesquioxides. On the slopes of the depression, the phenomena are more sharply pronounced; sometimes it happens that the brilliantly pink mud of the upper layer with remains of sandy rhizopods forms a sharp boundary on a rough surface consisting of bluish-gray clay-like mud with single grains of gravel and semi-decomposed carbonate remains (St. 1960, 389 m; fig. 98, 1, б). At the 31 to 34-cm marks of this core sample, an irregular stratification was observed, but from 35 to 38-cm, a horizontal stratification, with a layer of gray clay with ocherous ring, about 1 mm thick in the upper part, lying between two layers of fine gravel, sand and carbonate fragments. On the southern ledge of the bay (St. 2728, 235 m) a core sample contained greenish-gray sandy mud from 7 to 25-cm, which was interstratified with a rosy-gray clay-like sediment of marl type, which was also found by us on the Novaya Zemlya Shoal and in a section adjacent to /210

Fig. 98. Bottom structure of southwestern section of the Polar Basin Bay.

1 -- slope of Northeast (Nordaust) Bank: a -- St. 1945, 352 m; boxed core 43 cm long. Stratification of sediments from 1 to 11-cm and from the 21 to 28-cm marks of cores; б -- St. 1960, 389 m; from the 2 to 22-cm marks of cores. The pink mud 5 cm thick lies on a coarse surface; 2 -- slope on the extreme southern ledge of the Polar Basin Bay--St. 2728, 235 m; from the 16 to 46-cm marks of cores. Interstratification of greenish-gray sandy mud and rosy-gray marl.

the Central Depression (Tsentral'naya vpadina). "The marl" forms washed-up interlayers, it breaks into acute-angled pieces when dried cores are split up; the layer from 26 to 46-cm of the core consists of a continuous rock which is dense, heavy and nonsaline (fig. 98, 2).

In the southwestern branch of the Polar Basin Bay the underlying layers are not disclosed, but the cores reflect multiple shifts in the process of sedimentation. Thus a core 65 cm long obtained from the slope of Northeast (Nordaust) Bank (St. 1266, 290 m; fig. 99) hides three layers of pink sediments; at 10 to 12-cm and 32-cm of the lower strata of pink layers one can observe a dense dark pink interlayer, beneath it, a bluish-gray mud with pink interlayers and spots which assume a greenish-gray color toward the bottom. In a cross section between Cape Flora (Mys Flora) and Cape Hope (Mys Zhelaniya; fig. 97) the concretionary and ocherous interlayers were found at 7 and 11-cm of the cores (two cores - St. 1948, 195/250 m), at 15, 19 and 24-cm (St. 1949, 308 m; fig. 99), whereby a transitional layer, in which the inclusions of pink mud have acute-angled contours, was observed from 16 to 27-cm of the core samples. The interlayer is underlain by a bluish-gray, more clayey mud with calcareous inclusions, but between 43 and 46-cm, a longer core discloses an ocherous interlayer consisting of sandy and heterogeneous material lying on a rough surface of dense, heavy and dark noncarbonate rock. In the central section (St. 1950, 395 m), the thickness of the pink layer decreases to 6 cm followed by a greenish-gray mud which gradually grows into a gray uniform clay-like mud whose stratification is not clearly pronounced.

Fig. 99. Stratification of sediments in the Polar Basin Bay near the North-east (Nordaust) Bank.

1--St. 1266, 290 m; core 65 cm long. Three stages in the sedimentation of the pink mud in the Polar Basin Bay; 2--St. 1949, 308 m; cores 49 and 45 cm long. Brecciated character of transitional layer from 11 and 17-cm of the first core sample and between 16 and 27-cm of the second one. Concretionary interlayers between 43 and 46-cm of the first core sample and at 15-cm of the second one. Ocherous interlayers from 19 to 24-cm of the second core sample.

In the northwestern section of the Polar Basin Bay near the Shoal of Franz Josef Land (Zemlya Frantsa Isoifa; St. K813, 260 m; fig. 100) one can observe exposed dark gray dense and heavy mud with gravel and few carbonate remains, as in the case of the adjacent area of the Northern Plateau (Severnoye P.). On its surface lies a layer of sandy material with schist

and gravel, then follows a gray clayey interlayer which at 15-cm of the core is replaced by a greenish-gray layer out on the top by a pink mud which becomes more sandy toward the surface. On the eastern slope of a shallow ledge (St. K812, 193 m) one can observe interstratification of the upper and lower layers and curved fractures between the layers. Farther along the east-west cross section, the thickness of the pink layer increases, but at the greatest depth (St. K829, 385 m) along the stream /211 of Atlantic water penetrating here via St. Anna Trench (Zhelob Svyatoy Anny), the entire core consists of sandy mud with carbonate remains, the top of it having a pink color, the bottom a greenish-gray color. At depths 495, 465 and 419 m (St. K830, K831, K832) in the eastern portion of the bay, the thickness of the pink layer decreases from 10 to 3 cm; beneath the layer lies a viscous bluish-gray mud; at smaller depths, a less viscous mud with dense interlayers: at the depth of 257 m (St. K834 m) the interlayers are from 11 to 12-cm and from 20 to 21-cm; at the depth of 329 m (St. K833) from 6 to 7-cm and from 17 to 18-cm.

Similar variations in the structure of sediments are observed in the north-south direction: the contemporary yellowish-gray and greenish-gray sediment in the northern portion (at St. K803 for instance) is underlain by a rosy-gray clayey mud with gravel and carbonate remains without microfauna, but the upper layers contain the shells of foraminifera. Sometimes the underlying layer is represented by a dense nonsaline pinkish-gray clay-like mud (Stations K805 to K808) and is covered by a transitional layer consisting of a mixture of the upper and lower sediments. At great depths the

Fig. 100. Stratification of sediments in the Polar Basin Bay. 1--St. K825, 395 m; the lower section of the core between 20 and 36-cm. From 20 to 22-cm lies a yellowish-gray, slightly carbonaceous mud; 23 to 26-cm, a rosy gray clay-like mud; 26 to 28 cm, a ferrous interlayer marked by alternating reactions; 29 to 36-cm, a greenish-gray mud; 2--the northwestern slope: a--St. K813, 260 m; from 9 to 22-cm. Greenish-gray mud lies on a dense dark-gray mud with gravel (old) and containing little moisture. Sandy boundary layer at 16-cm mark; б --St. K812, 193 m; between 4 to 15-cm. Interstratification of yellowish-gray and gray mud. Curved boundaries.

underlying layer is not covered (St. K809, 396 m), but at a distance to the south the core ended in a dense and heavy yellowish-gray mud at the 27-cm mark; at a number of stations located to the west such mud formed a separate interlayer. With increase in depth and steepness of slope in the direction of Cape Hope (Mys Zhelaniya) one can observe a complex and irregular interstratification, which may be associated with landslides of /212
sediments (St. K825, 395 m; fig. 100), though a small number of depth measurements does not permit us to contour the submarine valley.

A complex stratification characterizing shifts in the regime of sedimentation was disclosed in the southeastern section of the Polar Basin Bay on the boundary with the Kara Sea. On a steep slope near Cape Hope (Mys Zhelaniya), a poorly sorted sandy mud with a large quantity of gravel and shingle was deposited, whose thickness sometimes is only 1 cm (St. 871, 313 m) and which is underlain by a gray or bluish-gray mud with gravel and shingle and with chitinous worm tubes and calcareous rhizopods. The cores obtained farther to the east (St. 872, 228 m; St. 874, 198 m) disclose a replacement down the core of bluish-gray mud by a denser greenish-gray mud or interstratification of rosy-gray light sandy interlayers (0.25 mm thick) with more clayey ocherous layers. The lower layer is represented by a rosy-gray, dense, heavy and slightly sandy mud with gravel and calcareous rhizopods. The same structure of the upper part of core is observed 40 miles to the north (St. 875, 310 m); here a sharp boundary is seen at the 6-cm mark of the core and farther down bluish-gray mud is gradually replaced (to 57-cm mark) by a greenish-gray mud with ocherous inclusions.

The cores obtained from the northeastern section of the Polar Basin Bay between long. 69 and 70° E (M. M. Ermolaev, 1948) are also marked by a complex stratification with concretionary interlayers, as we had observed it in the Kara Sea in 1927. About 30 miles to the east of the north-south cross section (Stations K800, K801, etc.), the pink mud layer 18 cm thick (St. 45/73 B, by Sadko; according to M. M. Ermolaev) was underlain by a dense layer of dark gray sediment which in the lower part was intersected by a brilliant orange interlayer. An elastic bluish-gray (according to M. M. Ermolaev, a grayish-blue) mud continues to 52 cm; from 53 to 57-cm, a nonelastic darkish-pink mud; and to the end of core (to 88-cm), a blue mud with dark spots. M. M. Ermolaev attributes the origin of the dense interlayers to a lithogenic process associated with the activity of micro-organisms during the period marked by the intrusion of intensified Atlantic currents in the northern portion of the Kara Sea (Karskoye more). Regrettably, the mechanical analysis was carried out, not for individual layers in the cores but for the mean samples along sections 10 cm long. It was, in addition, done by the Robinson method and does not enable us to compare the mechanical composition of cores obtained by M. M. Ermolaev with other data based on collections obtained from the Barents Sea. As the writer himself notes, it is impossible to establish any regularity in the variation of mechanical composition along the vertical. Judging from the quantity of fractions ranging from 0.05 to 0.01 mm in a triangular diagram, fluctuating between 30 to 40%, the sediment is represented by mud or by a clay-like mud verging on mud.

The graphical presentation of the mean mechanical composition for the sediments of Polar Basin Bay (table 16) shows abrupt variations in mechanical composition at depths with a great gradient, i.e. on steep slopes, and the absence of a direct link with changes in depth (fig. 91). The curve for particles ranging from 1 to 0.1 mm in the sandy mud interval is associated with their lying on a steep slope near Cape Hope (Mys Zhelaniya). The same cause brings about the appearance of a bend in the curve representing the particles ranging from 0.1 to 0.05 mm; the bends in the curve representing the fine silt in the sandy mud interval result from an excessive inflow of new material in connection with outwash deposits of fine-grained sediments, but in the mud interval, in which the particles that are smaller than 0.01 mm constitute 30 to 40%, the bends result from cementation of sediments with sesquioxides.

22. The General Pattern

A detailed examination of the composition of the Barents Sea sediments by individual geomorphological areas enabled us to clarify a number of new patterns and define others that had been established before. Thus it appears that the distribution by depth of individual types of sediments /213 depends not as much on absolute magnitudes as on the amplitude of fluctuations in bottom relief and on the steepness of slopes.

As we had seen before, on each topographic feature the changes in mechanical composition of sediments are influenced by changes of depth, but when comparing individual topographic features among themselves and even

individual areas on the same slope, which have different exposures, and even more so in cases of areas of more than one slope, the fluctuations in mechanical composition can be explained only by a hydrodynamical setting associated with the combined action of permanent and tidal currents and waves, i.e. in hydrodynamical activity. Thus for instance, the increase in the size of material can be seen on underwater slopes in areas where the Atlantic currents are generated - i.e. on the southern slope of the Nordkapp Trench, the northern slopes of the Murman Kanin and Gusinaya Banks, the western slopes of the elevation of Gorbovye Islands (ostrova Gorbovy) and on the Spitsbergen-Bear Island (Medvezhinsoye) Shoal.

A considerably smaller rate of increase in the size of sediments is observed on slopes having a reverse exposure, on the eastern slope of Hope Island-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye) for instance, where the muddy sand and sandy mud are deposited at shallower depths than on the southern slopes, and partly also on the eastern slope of the Central Elevation which is crossed by slower flowing Barents Sea waters.

One can notice in various areas of the sea that when the bottom relief becomes sloping, even at the same or a decreasing depth, rather quiet zones are formed; this leads to the deposition of a finer grained material (fig. 71).

Due to hydrodynamical regime, the sediments having different types of graphs relative to their mechanical composition are marked by a regular

distribution pattern with respect to relief. In areas of normal sedimentation, single-apex graphs predominate for the muddy sand consisting mostly of coarse silt particles, and for the sand having sometimes the same composition, but in areas marked by enrichment with coarse materials (on slopes) having a maximum of sand particles. In areas characterized by normal sedimentation, the graphs for sandy mud have also a maximum of coarse silt; mud and clay-like mud, a maximum of silt particles.

As an example of sediments characterized by normal sedimentation one can mention the muddy sand of Pre-Kanin area, the sandy mud on the slopes of the Central Elevation, mud at the eastern end of the Nordkapp Trench and on the Northern Plateau (Severnoye Plato), clay-like mud in the same areas and so on.

A peculiar position is occupied by the mud having a maximum of fine silt particles. Such a graph usually characterizes the sediments that have been deposited in calm areas and that become firmly cemented when in dry state, evidently with the predominance of organic substances. Almost always the graphs pertain to greenish-gray sediments having a peculiar viscous and lumpy structure.

A detailed morphological investigation of sediments by binocular microscope shows that a two-apex graph of mechanical composition of any sediment type is explained by the presence of lumps of fine-grained particles among coarser material. It has been pointed out more than once (M. V. Klenova, 1948, et al.) that such a character of sediment is associated

with the absence of equilibrium between the hydrodynamical regime and the sediment. As can be seen from the description of the Barents Sea sediments by areas, the two-apex graphs and the corresponding structure of sediments are primarily confined to cores consisting of two layers. In the upper layer of the cores one can distinguish - sometimes visually by naked eye, sometimes by binocular microscope, an admixture of lumps of the underlying layer differing from the upper layer by its mechanical composition and by color (for instance, St. 941 on the Murman Shoal, St. /214 1012 in the Western Trench, St. 315 in the area of Western Commercial Banks, St. 1891a on the Bear Island Bank-Medvezhinskaya banka, etc.). In some core samples consisting of two layers, especially in case the difference between the composition of the upper and lower layers -- when the color is the same, for instance -- is small, it is impossible to notice morphologically the admixture of particles from the lower layer, and the presence is expressed only by a two-apex graph of mechanical composition (for instance, St. 1070 in the Nordkapp Trench, St. 1033 on the Persey Elevation). In all these cases the bottoms of core samples hide the underlying layer of a different composition, whereas the sediment of the upper layer has a visually irregular structure.

Increase in the size of material on slopes and the appearance of two-apex graphs of mechanical composition agrees well with the decrease in thickness of deposits. Most of the shoals of the Barents Sea (fig. 14) are characterized by an insignificant thickness of the Recent sediments which are underlain by sediments of a different composition and, sometimes, by accumulations of outwash deposits occurring in situ. The small length of

the cores does not enable us to determine the thickness of the Recent layer in the entire area subject to investigation, but the existing data enable us to single out a number of areas (fig. 101) where the thickness of Recent sediments does not exceed 50 cm, but at times even 10 cm. As can be seen from fig. 101, the underlying layer of sediments has not been enriched in the entire southeastern part of the Barents Sea. Even on positive relief elements and on steep slopes, in the area of Gusinaya Bank and in Pre-Novaya Zemlya (Prinovozemel'skiy) Trench, for instance, we have at our disposal samples with two layers. With respect to the Gusinaya Bank there are individual indications by captains of trawlers that a layer of clay has been found under coarse-grained material, but the quantitative data relative to the thickness of the upper layer are absent. In part, this is associated with the fact that the corers whose firmness is limited had not penetrated the upper layer of the area and that it was determined mainly on the basis of samples collected by the bottomgrab.

The character of mechanical composition of sediments in this section of the sea permits us to consider it as an area marked by normal mechanical differentiation of sediments, i.e. as an area of accumulation. As we shall see later, this will be confirmed also by other lithogenetic characteristics of the given area.

The northern slope of the Murman Bank and partly that of the Western Commercial Banks are areas marked by a thin layer of Recent sediments in the Murman Bank area. Here, beginning from the Murman Coast (Murmanskiy bereg), and on the Murman Shoal, the Kil'din Bank and in other areas, the

old underlying layers (probably Quaternary) of clay are covered only by a thin layer (less than 10 cm) of Recent sand and muddy sand. At places they are almost completely denuded on the bottom and can be reached everywhere by the boards of commercial trawls. Areas characterized by a minimum thickness of sediments are confined primarily to the northeastern slope of the Varanger Peninsula (Varangerhalvøya), Rybachiy Peninsula (poluostrov Rybachiy), Kil'din Island (ostrov Kil'din) and also to the western and northwestern ledges of the Murman Bank. On the whole, the thickness of sediments on the Murman Bank does not exceed 20 cm at depths to 200 m and increases to 50 cm northwestward in the direction of the Western Commercial Banks. The same (less than 50 cm) applies to the thickness of Recent sediments on the southwestern slope of the Murman Bank to the north of the extreme eastern branch of the Nordkapp Trench and at the great depths along the base of the slope of Varanger Island (Varangerhalvøya). The thickness of Recent sediments at the entrance to the Varanger Gulf and on its submarine slope is also insignificant, where at places the old morainic clay lies denuded on the bottom.

Farther to the north, one can find areas characterized by thin deposits of Recent sediments on the Central Elevation, on the Persey Elevation and in the area of the Northern Plateau (Severnoye Plato). On the Central Elevation one can find a relative increase in the thickness of sediments in the underwater gulf of the southeastern section. On individual elevations the thickness decreases 3 to 5 cm. In a number of areas of the Persey Elevation, investigators have found that older rocks are thinly /215

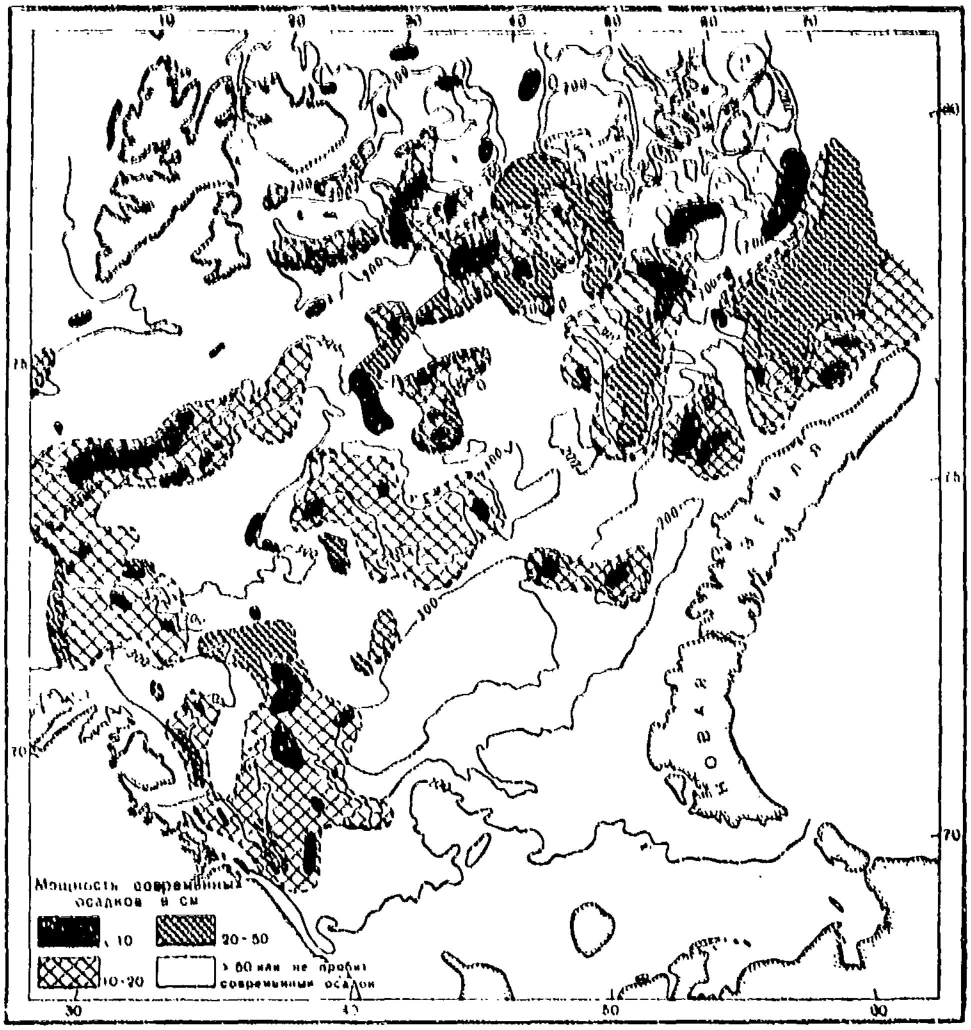

Fig. 101. The thickness of Recent sediments in the Barents Sea.

Key. Lower left-hand corner:

Thickness of Recent sediments in cm

10	20 to 50
10 to 20	more than 50 of the Recent sediment has not been penetrated.

covered (less than 10 cm) and that cores have disclosed the entire underlying layer on the whole surface of the elevation. Insignificant thicknesses of Recent sediments has also been observed on the entire expanse of the Northern Plateau (Severnoye Plato). Even in a deep trench, such as the branch of the Franz-Viktoriya Trench, the thickness of the Recent layer does not exceed 50 cm. In many places on positive relief elements the thickness is smaller than 10 cm. Here, as we have observed before, the outcrops of in situ sediments have been disclosed beneath a thin layer of Recent sediments (for instance, at Stations K501, K486, K499 on the underwater slopes of the White (Kvitøya) and Viktoriya Islands).

On the Novaya Zemlya Shoal in the eastern section of the sea, a thin layer of sediments has been found on the elevation of Gorbovyye Islands (ostrova Gorbovy) and on the Novaya Zemlya Bank (Novozemel'skaya banka) to the west of Matochkin Strait (proliv Matochkin Shar). To the north, the old sediments covering the underwater slopes of the Polar Basin Bay are being denuded. The thickness of Recent sediments increases with depth.

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The distribution of thickness on the underwater slopes of the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye) has a very typical pattern. Thin belts are stretched out along the southeastern and part of the western slopes. The western part of the Barents Sea almost throughout the Cape Nordkapp-Bear Island (Bjørnøya) cross section is characterized by a thin layer of contemporary deposits. A belt marked by a thin layer of Recent deposits (10 to 12 cm), which covers an area of the Western Commercial Banks, extends also along the submarine threshold

separating the Bear Island (Medvezhinskiy) Trench from the great depths of the Greenland Sea. At places the thickness of Recent sediments is less than 10 cm. At the base of the Bear (Medvezhinskoye)-Spitsbergen Shoal, the thickness increases to 20 to 50 cm. A gradual increase in the thickness can also be established in a westward direction, as well as in the central part of the Western Trench.

Thus the material discussed with respect to the Barents Sea enables us to single out two types of areas marked by a very thin section of Recent sediments: first of all, the surface and submarine slopes of positive relief elements - the Murman Bank, the Central Elevation, the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) and the bank of Gorbovyye Islands (ostrova Gorbovy), the Persey Elevation and the bottom elevations connected with it, the Northeast (Nordaust) Elevation; secondly, the depression areas of the Northeast (Nordaust) Elevation, the Polar Basin Bay, the Franz-Viktoriya Trench and a portion of the western end of the Bear Island (Medvezhinskiy) Trench.

As was already pointed out, in many instances the thin section of Recent sediments determined on the basis of cores consisting of two layers agrees with the poorly sorted material and the two-apex graphs of mechanical composition. One can think that the thinness of sediments on the positive relief elements and on steep slopes is determined by the active hydrodynamical regime when water movements wash away the sediments that had been deposited before.

The active erosion of the fine-grained material from the sediments on the positive relief elements is well defined by the distribution of sand particles (1 to 0.1 mm). The graph for sand particles (fig. 102) demonstrates that the quantity of sand in the cores that have been analyzed does not always increase toward the coast. The quantity of sand particles exceeding 50% is found in a narrow coastal belt on the slope of the Nordkapp Trench and on the steep slope of the Northern Shoal of Novaya Zemlya near Cape Hope (Mys Zhelaniya), as well as on individual elevations of the Murman Shoal (Murmanskoye melkovod'ye). A similar enrichment of sand particles is observed on the Kanin Bank (Kaninskaya banka) at depths of approximately 100 m, on its slope leading to the Central Depression as far as 300 m and on the southern and western slopes of the Goose Bank (Gusinaya banka). Sand particles constitute more than 50% of sediments in the Pechora Sea (Pechorskoye more) to the north of Pechora estuary and in smaller individual areas - namely: on the Persey Elevation and Bank, on the slope of Nordbruk Island (ostrov Nordbruk) and on the western slope of Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye).

A considerable enrichment of sand particles - from 20 to 50% - is observed in the entire southeastern part of the Barents Sea, except for the Pre-Novaya Zemlya (Prinovozemel'skiy) Trench and a muddy spot in the Zakolguyev area (area beyond the Kolguyev Island. Tr.). The same situation exists on the northern slope and on the surface of the Kanin (Kaninskaya), Murman (Murmanskaya) and Goose (Gusinaya) banks, on the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye), on almost the entire surface of the Northern Shoal of Novaya Zemlya, on the Persey Bank and in

individual areas, for instance on the Central Elevation and elsewhere. A diminution of sand particles in the sediments is observed in the peripheries of the mentioned areas. However, sediments containing from 10 to 20 % of sand are rather widely distributed. They cover the bottom of the Murman Shoal (Murmanskoye melkovod'ye), the area of the Western Commercial Banks (Zapadnyye promyslovyye banki), the eastern slope of the /217
Central Depressions, the northern portion of the Novaya Zemlya Shoal (Novozemel'skoye melkovod'ye) and are widely distributed over the surface of the Central and Persey Elevations, especially on its southeastern ledge. As the distance from the centers of these areas increases, the quantity of sand particles rapidly becomes nil and the sediments containing from 5 to 10% of particles ranging from 1 to 0.1 mm form only a narrow belt around the areas enriched with the particles.

The Central and Northeast (Nordaust) Depressions, almost throughout the entire expanse of the Northern Plateau (Severnoye Plato), except for the areas adjacent to islands and in the Western Trench are covered by sediments containing a small quantity of sand particles, despite their differing mechanical composition. This in all probability attests to their local origin. As to the coastal areas, it can be assumed that the source of sandy material lies in the products resulting from destruction of coastal rocks which are gradually broken up and sorted by the sea waves. However, such an assumption does not explain the enrichment of positive relief ele- /218
ments with sand material at considerable depths. Here, as correctly pointed out by V. P. Zenkovich (1938) with respect to the Goose (Gusinaya) and

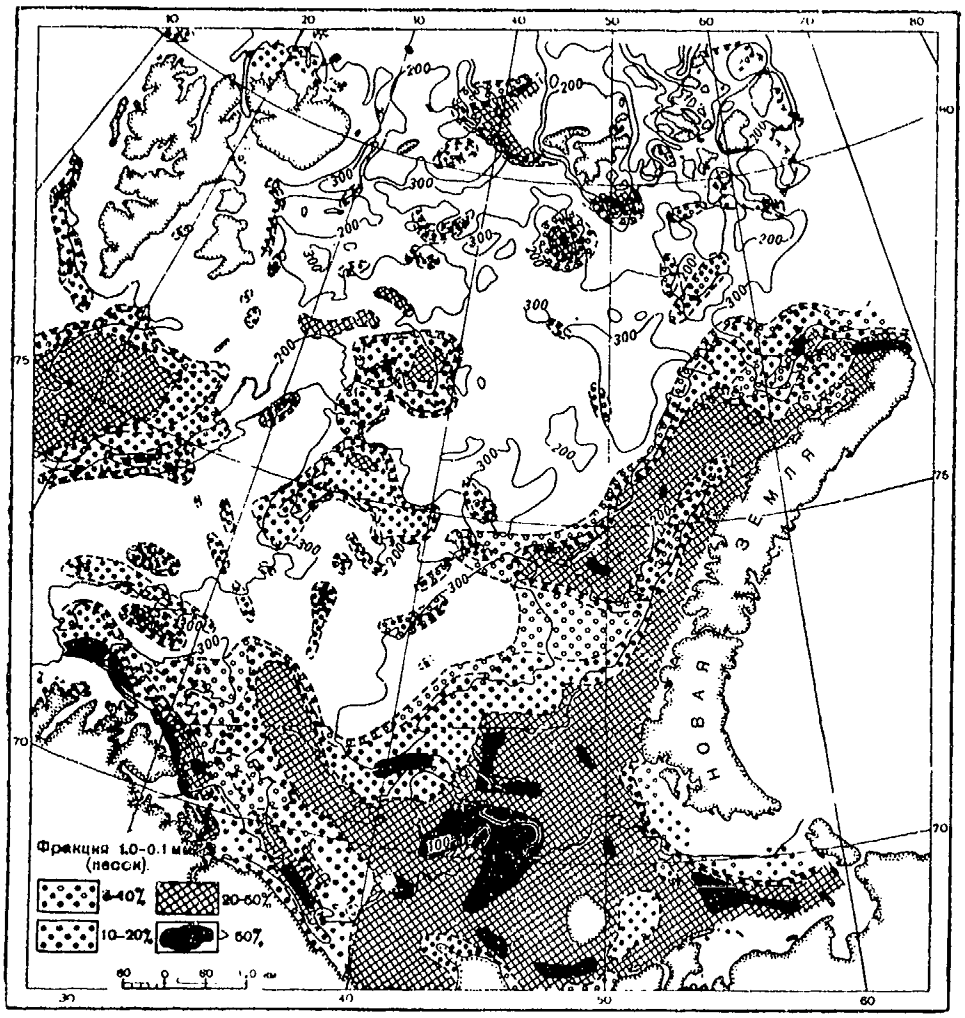

Fig. 102. Distribution of sand particles ranging from 1 to 0.1 mm in the Barents Sea.

other banks in the southern portion of the Barents Sea, the older rocks eroded as a result of fluctuations in sea level can serve as a source of sand material.

Comparing the charts showing the thickness and distribution of sand particles (fig. 101 and 102), one can notice the differences in the areas characterized by a thin section, which were discussed above. On positive relief elements (for instance on the Murman Bank, on the slope of Bear (Medvezhinskoye) Shoal, on the Central Elevation and on the Persey Bank and elsewhere), the thinness of Recent sediments is accompanied by an enrichment in sand particles. In depressions the quantity of sand particles is very small and the thinness of Recent sediments is not explained by erosion of older sediments but by a slow rate of sedimentation.

The mentioned distribution of sand particles attests to the fact that the concept of the great role played by ice in the transport of sediments has been exaggerated to a considerable degree. An increase in the quantity of sand particles is observed without any connection with the distribution and melting of ice and can be well explained by the reciprocal action of hydrodynamical regime and bottom relief.

When examining the distribution of a more coarse-grained material, such as gravel and small shingle (the size of particles exceeding 1 mm), in the sediments, we can find (fig. 103) that the enrichment of the sediments with these components is also associated primarily with the areas characterized by active hydrodynamical regime and erosion of old sediments. A

great quantity of gravel (more than 50% and from 20 to 50%) has been found in the vicinity of islands and on steep slopes: at Cape Hope (Mys Zhelaniya), near Cape Nordkapp, at Cape (Mys) Svyatoy Nos, near individual capes of Novaya Zemlya,at the White Island (Kvitøya or ostrov Belyy) and elsewhere, as well as on the submarine slopes of the Western Spitsbergen and the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye). Sediments containing the same amount of gravel are found at places on the Central Elevation, on the northeastern spur of the Persey Elevation, in the Pechora Sea (Pechorskoye more), on the banks of Gorbovyye Islands (ostrova Gorbovy), and so on. In addition to the mentioned areas, a noticeable quantity of gravel (from 1 to 10%) was observed in the Pre-Kanin area, in the coastal belt of the Murman Shoal (Murmanskoye melkovod'ye), near Novaya Zemlya, on the Central Elevation, especially in its western portion, and on the southeastern spur of the Persey Elevation. Thus, the great amount of gravel is not associated with the distribution of ice but it agrees well with the thinness of Recent deposits on the positive elements of bottom relief.

Also the distribution of coarse fragments, such as shingle and pebble (stones) is subjected to the same rule (fig. 104). Great quantities of stones caught by trawl and bottomgrab[1] have been observed on the slopes of the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye) on the northeastern spur of the Persey Elevation, on the Persey Bank near

[1]Determination of the weight of stones in samples taken by bottomgrabs (on 1 m^2 area) and the evaluation of the number of stones collected by trawls was not done during all the cruises. These data are incomplete and they permit us to draft only a rough scheme as to the distribution of coarse fragments.

Cape Hope (Mys Zhelaniya) and on the bank of Gorbovyye Islands (ostrova Gorbovy). Individual areas rich in coarse fragments have been found in the Pechora Sea (Pechorskoye more), on the slopes of Goose (Gusinaya) Bank, on the Kanin and Murman Banks. In areas where mud-like sediment accumulates in depressions, as well as in the well sorted sand sediments on the Murman Shoal and in Pre-Kanin area, rock fragments are seldom found.

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The composition of boulders demonstrates (M. V. Klenova, 1937) that each relief element of the Barents Sea plain is characterized by a peculiar collection of rocks. On the basis of the data collected by V. P. Zenkovich[1], we have preliminarily singled out types of boulders of the Murman Shoal, the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye), Franz Josef Land, Novaya Zemlya, the Pechora area, the Pre-Kanin area, the Central Elevation and the deep region (fig. 105, a to z). Also the presence of a special arrangement peculiar only to the Central Elevation, the Central Plateau (depth complex) and certain other relief elements underscores the assumption that rocks are found nearby and that the effect of ice on the transfer of coarse materials is relatively weak in comparison to the generally accepted view.

[1] The investigation of boulders was done jointly with V. P. Zenkovich.

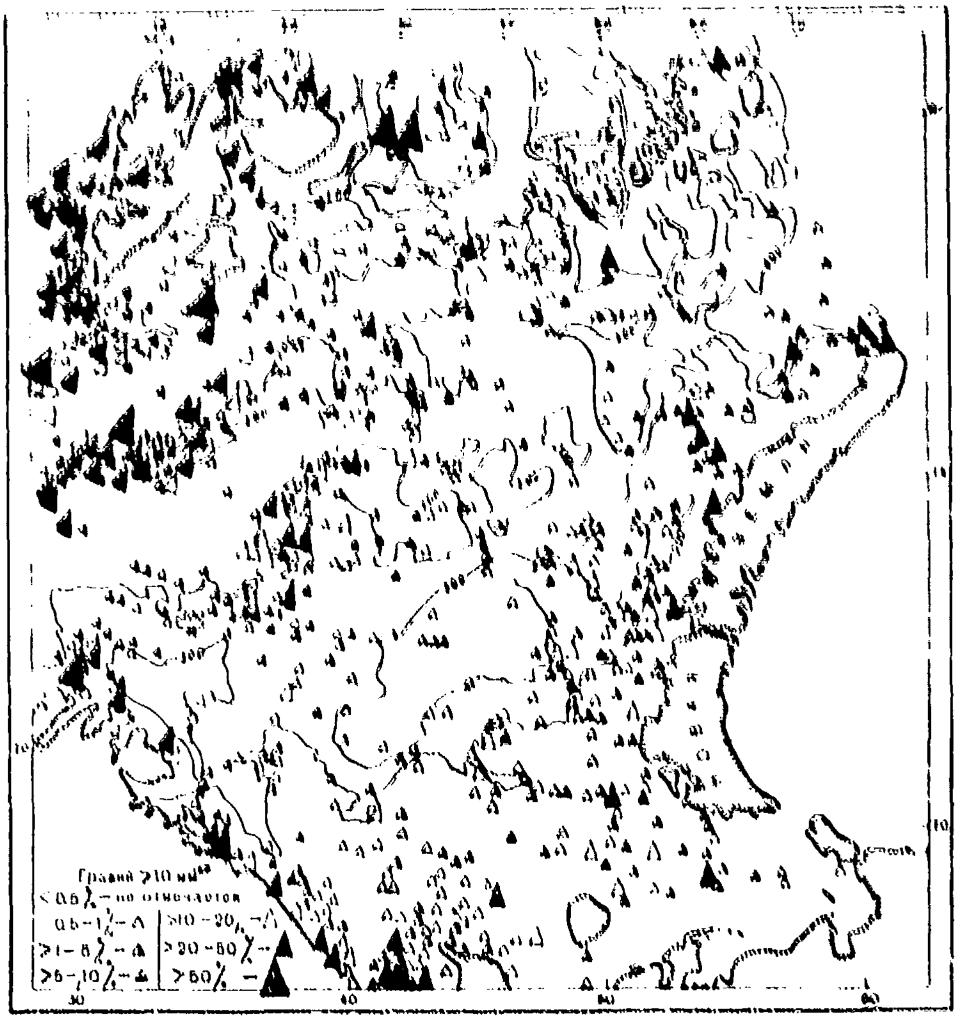

Fig. 103. Distribution of gravel and small shingle in the sediments of the Barents Sea (fragments exceeding 1 mm).

<u>Key</u>. Left-hand corner at the bottom of figure:

Gravel smaller than 10 mm.

Less than 0.5% is not taken into consideration.

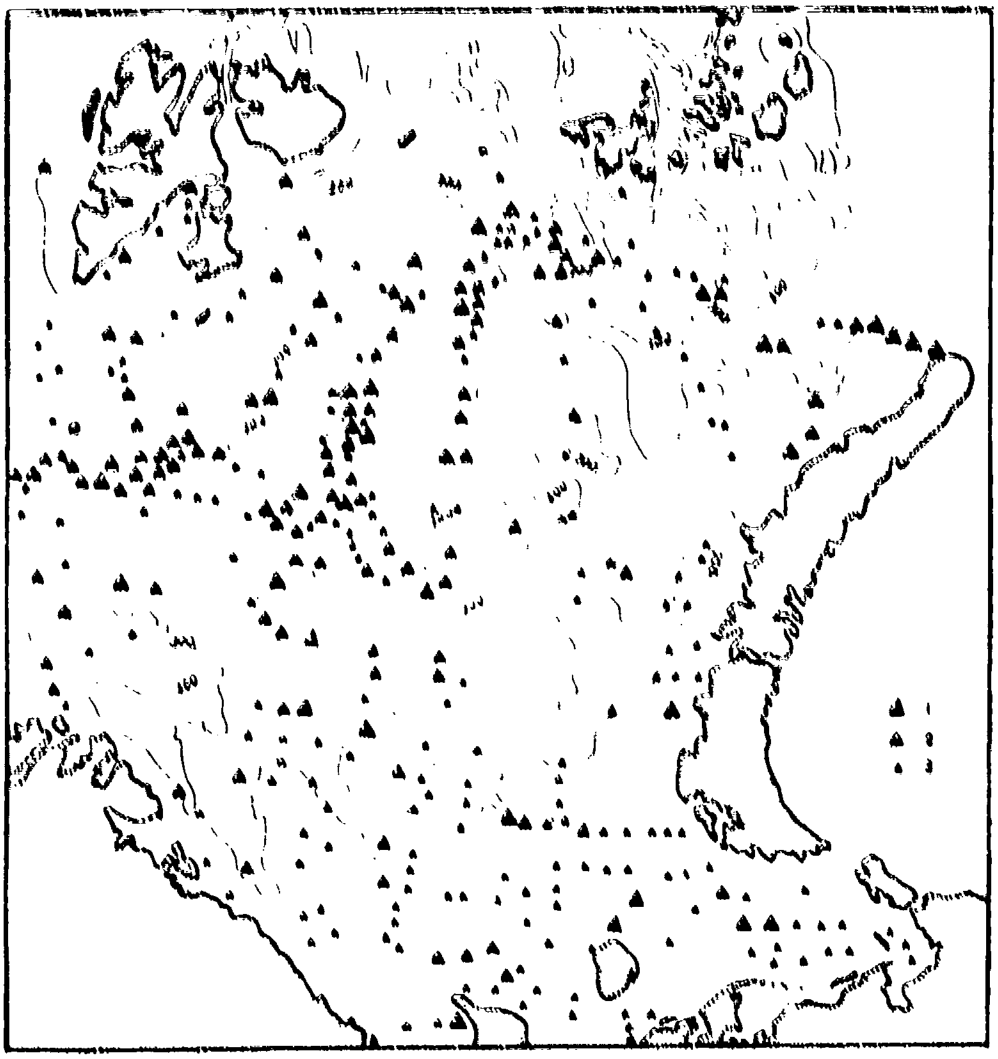

Fig. 104. Distribution of coarse material, such as shingle and pebble (stones) in the Barents Sea.

1 — 5 balls; 2 — 4 balls; 3 — 3 balls and less.

The question on the age of the sediments that underlie the Recent deposits shall be discussed later (in a section on stratification). However, when comparing the data as to the thickness and mechanical composition of the surface layer on various relief elements with the origin of the elements, we can determine the character of the latest movements on the Barents Sea plain with a considerable degree of assurance (fig. 105). In addition to the continent along the northern coast of Fenno-Scandia, Spitsbergen, Franz Josef Land and other islands, as well as Novaya Zemlya, the northern shoal of Novaya Zemlya can be assigned to the group of elevated areas. The thinness of Recent sediments, enrichment with sand particles and the diversity in the composition of the underlying layer, which reflect the composition of in situ material, support this supposition.

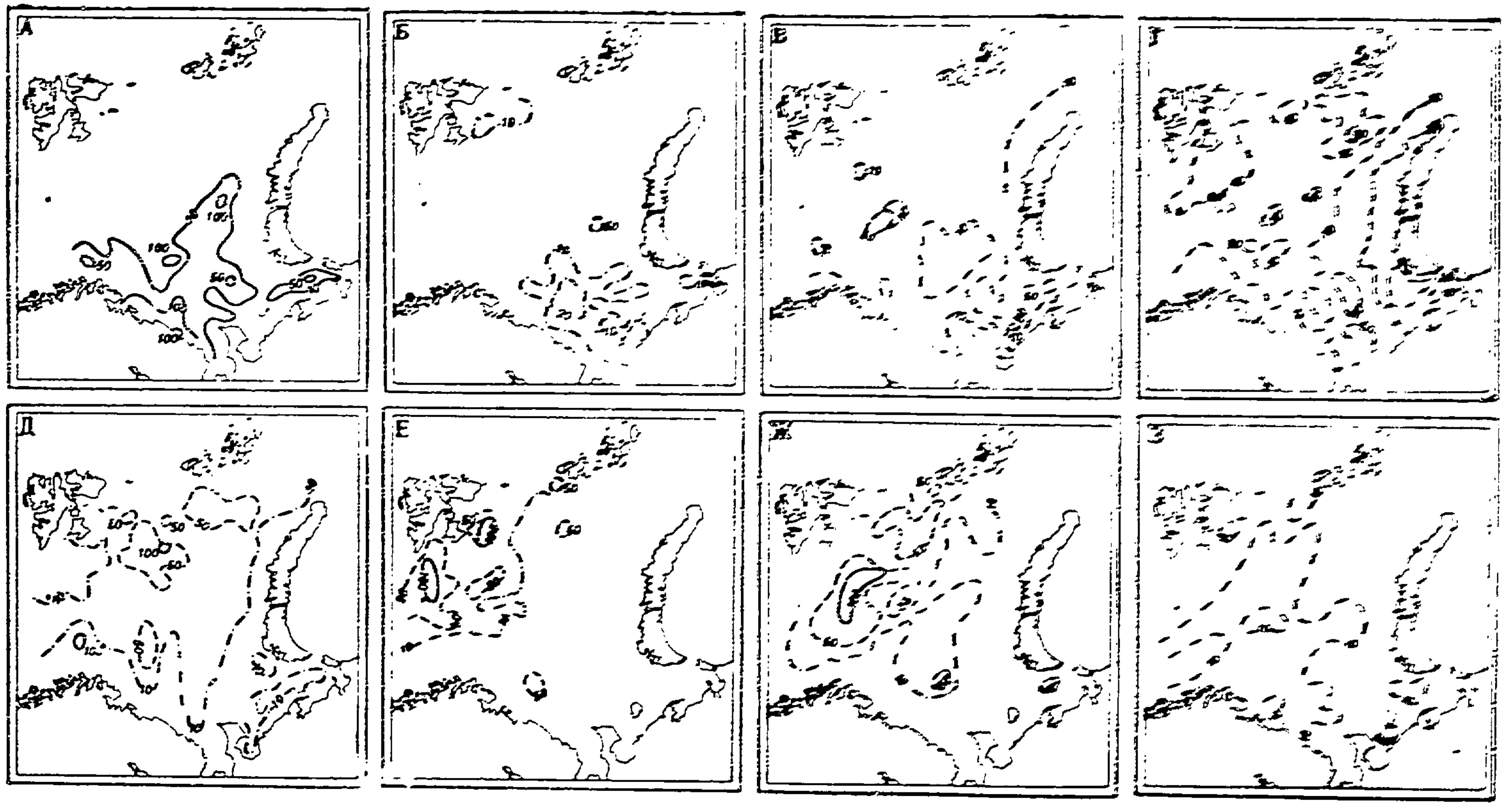

Fig. 105. Composition of Boulders.

а -- the Murman complex; б -- the Kanin complex; в -- the Pechora complex; г -- the Novaya Zemlya complex; д -- complex of Franz Josef Land; е -- the Bear-Spitsbergen complex (Medvezhinsko-Spitsbergenskoye); з -- the depth complex. (Compiled by M. V. Klenova on the basis of data by V. P. Zenkovich).

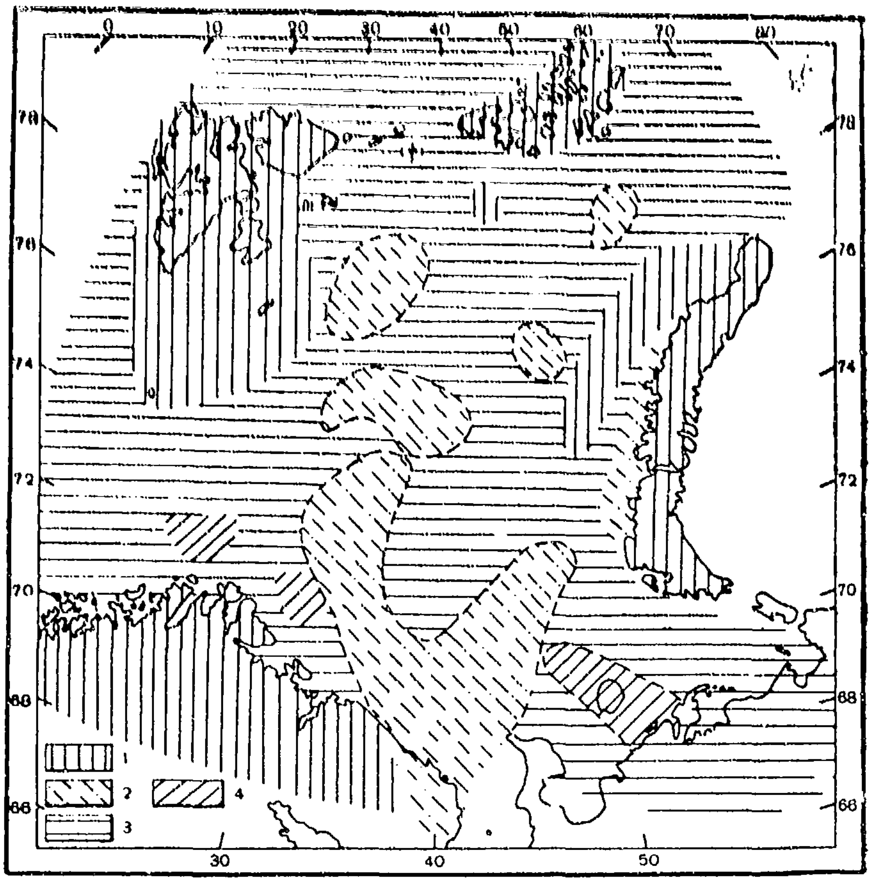

Fig. 106. The latest tectonic movements on the Barents Sea Plain.

1 — elevations; 2 — relative elevations; 3 — depressions;

4 — relative depressions.

The entire region of the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye), where intense erosion of the underlying layers is taking place at the present time, especially on steep slopes, can be considered as an area of Recent elevation. The fact that the in situ eroded material lies near the surface on the slopes of King Karl Islands (Kong Karls Land or Kongsøya), Viktoriya Island (ostrov Viktoriya) and the Persey Bank on the Northern Plateau indicates to us that the process occurs in the same direction. As was pointed out, the underlying layers have been found only on the slopes of the Persey Bank, especially on the steep slope leading to the Franz-Viktoriya Trench. Therefore it would perhaps be more correct to consider the area as being characterized by a relative elevation. The latter group includes the Persey Elevation, the Northeast (Nordaust) Bank, the Central Elevation, the elevation between the northern portion of the Central and the Northeast (Nordaust) Depressions, the area of the Central Plateau, the Murman, Kanin and Goose Banks (Gusinaya banka). The underlying layer, which appeared to be denuded in some core samples, indicates the presence of a diverse composition of eroded material in certain locations. These areas, adjacent to the Central Depression of the Barents Sea, can be considered only as areas of a relative elevation against the general background of depression. The Central and Northeast (Nordaust) Depressions, the Western Trench, the /223
Pechora area, the northern trench of Novaya Zemlya (Severo-Novozemel'skiy zhelob) separating the northern shoal of Novaya Zemlya from the coastal areas of the island are assigned by us to depression areas. Also the area of the Northern Plateau, which is connected with the depressions of Franz-

Viktoriya Trench, of the Polar Basin Bay and others merging with the slope of the Arctic Basin and marked by intense sagging have to be considered as depression areas. Evidently, the sagging in the Kolguyev area, at the western spur of the Murman Bank and in the area of the Western Commercial Banks (Zapadnyye Promyslovyye banki) occurs at a considerably slower pace.

While examining the distribution of sediments on the surface of the Barents Sea Plain by profiles and individual areas, we had the opportunity to notice that each characteristic of the mechanical composition of the sediments conforms with the physical-geographical conditions of their deposition and, most of all, with the morphology of individual elements and the character of slope determining the hydrodynamical regime. These rules have been established long ago, but the vast material utilized in describing the Barents Sea floor enabled us to define them more closely. In addition to the close link between the mechanical composition of sediments and the conditions of their deposition, numerous analyses enabled us to detect the meaning of the reciprocity (interchange) existing between individual particles which we divide a sediment into when carrying out mechanical analysis.

The graphs of the mean mechanical composition by individual areas, for which there have been from 31 to 166 analyses per area (altogether 1566 analyses) utilized, demonstrate the regular character of the reciprocity (interchange). Two basic types of graphs were established. In certain areas the increase in silt particles (less than 0.01 mm) is accompanied

by a uniform decrease or corresponding increase of other particles. This is well expressed on the Kanin-Kolguyev Shoal, the Central Plateau, in the Northeast (Nordaust) Depression and, to a slightly smaller degree, in the Pechora area (fig. 43 and 91). With the increase in the quantity of silt particles in the areas, the quantity of sand and coarse silt particles decreases uniformly, and the quantity of fine silt (0.05 to 0.01 mm) increases uniformly. In other areas, changes in the quantity of coarse silt particles do not occur uniformly with an increase of silt particles. Here, in turn, one can single out several specific types of graphs. Thus, in the Nordkapp Trench, in the Pre-Kanin area, on the Central Elevation, on the slope of Spitsbergen and the Polar Basin, in the Bear Island (Medvezhinskiy) Trench and in the Polar Basin Bay (fig. 35, 60, 74, and 91), the curve characterizing the composition of sand particles (1 to 0.1 mm) forms a convexity in the interval of muddy sand or sandy mud (from 10 to 20% of particles smaller than 0.01 mm); this attests to a supplementary inflow of sand material, which has evidently been washed off the steep slopes. In a number of graphs, an increase in sand particles is also accompanied by an increase in the quantity of coarse silt particles (the Nordkapp Trench, Central Elevation, underwater slope of Spitsbergen; fig. 35, 60, and 74).

Sometimes with a uniform increase in the quantity of sand particles, when the material is being broken up, the quantity of coarse silt increases, most frequently, in the muddy sand and coarse-grained sandy mud interval. This is observed on the Murman Shoal, on the Murman Bank, in the area of Western Commercial Banks (Zapadnyye promyslovyye banki), on the Goose Bank

(Gusinaya banka) (fig. 35), where the quantity of coarse silt increases, which occurs also in a more fine-grained sandy mud interval; on the shoal of the southern and northern islands of Novaya Zemlya, on the Bear Island-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye), on the Northern Plateau and in the area of the Central Depression (fig. 60, 74 and 91) the quantity of fine silt sometimes changes by degrees, increasing in the sandy mud or mud interval, but sometimes increasing uniformly with /224 an increase in the quantity of particles smaller than 0.01 mm.

The appearance of definite points causing the delineation of curves characterizing the mean mechanical composition enables us to state that the complex character of curves having numerous bends reflects the inflow of new material during the process of normal mechanical differentiation and sorting of sediments by their mechanical composition. The complex curves of mechanical composition are primarily characteristic of the areas consisting of slopes which are being actively eroded and of areas where in situ materials lie nearby.

The most complex graphs are confined to the Nordkapp Trench, the Murman Bank, the area of Western Commercial Banks (Zapadnyye promslovyye banki), the Goose Bank (Gusinaya banka), the Central Elevation, the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye) and partly to the Persey Elevation, the Northern Plateau, the Western Trench and to the Polar Basin Bay. The absence of sufficiently detailed data on the hydrodynamical regime of bottom waters does not permit us to associate the peculiarities of mechanical composition of sediments with the characteristics

of hydrodynamical regime, except for the very general comparisons mentioned above when describing the areas.

In order to describe completely the mechanical composition of sediments, it is also necessary to have data for the composition of particles smaller than 0.01 mm, because, according to the accepted method, the particles in the usual process of analysis are eliminated by means of elutriation. For a number of the Recent and the underlying sediments in the Barents Sea one can utilize to a degree the data of analyses obtained by the pipette method. The methodical studies by M. V. Klenova and K. A. Rachkovska (1933) of sediments in the open part of the Motovski Gulf (Motovskiy zaliv) demonstrated that the resultant quantity of particles smaller than 0.01 mm, obtained by the pipette method, always exceed the quantity of the fragments determined by the elutriation method using the microscope to control the grain size.

The ratio changes with the various methods of preparing a material for analysis, but it remains similar for sediments having a related mechanical composition if the preparation is the same. For the muddy sand and the sandy mud of the Motovski Gulf (Motovskiy zaliv), it equals 0.66 at moistening, and 0.42 if before elutriation the sample is preliminarily moistened for several days, but for the analysis by the pipette method the material must be boiled for one hour. The boiling, as it was also demonstrated for the elutriation method (M. V. Klenova, 1926), increases by 1.5 times the quantity of particles that are smaller than 0.01 mm. As could be expected, the larger particles are subjected to disaggregation, which leads to an increase in the quantity of particles ranging from 0.01 to 0.001 mm, whereas the quantity of smaller particles changes insignificantly, sometimes

even decreasing, which is evidently the result of coagulation.

In order to clarify the composition of the tiny sediment particles in the Barents Sea, in addition to the Motovski Gulf (Motovskiy zaliv), we have at our disposal the analyses of the surface and the underlying layers of sediments on the Murman Shoal (L. A. Iastrebova-Lidova, 1948), where the investigations dealt with the muddy sand, the sandy mud and the old marl (gray clay), and also analyses of the sandy mud from the Bear Island Bank (Medvezhinskaya banka; St. 1893, 197 m), the Central Plateau (St. 1060, 269 m), analyses of layers of a core taken from the Polar Basin Bay (St. K824, 422 m), analyses of mud obtained from the Novaya Zemlya Trench (Novozemel'skiy zhelob) (St. 371, 181 m) and from the slope of the Polar Basin (St. K794, 231 m). In other words, they shed light on various areas of sedimentation (table 17).

Despite differences in the conditions of sedimentation and certain differences in methods, the listed data enable us to notice a number of rules: (1) the quantity of fragments smaller than 0.01 mm and determined by the summation of individual fragments always exceeds the results obtained by analysis based on the standardized method of the Marine Geological Laboratory by controlling the size of grains with the aid of microscopes; (2) changes in the mechanical composition of sediments consisting of fragments smaller than 0.01 mm and based on the same method are reflected

Table 17

MECHANICAL COMPOSITION OF THE TINY SEDIMENT PARTICLES IN THE BARENTS SEA BY THE PIPETTE METHOD.[1]

Stations	306, 214 m	263, 212 m	147, 160 m	258, 129 m	1060, 269 m	1893, 197 m
Quantity of fractions smaller than 0.01 mm by the method of elutriation in percentages	9.3	9.9	11.1	11.4	17.7	22.2
Fragments in mm:						
greater than 1	(0,06)	(0,31)	(1,84)	(0,54)	(4,17)	0,04
from 1 to 0.1	5,43	8,89	22,79	3,86	9,51	1,41
" 0.1 to 0.01[2]	84,53	81,36	59,35	87,80	68,32	74,17
" 0.01 to 0.005	3,85	6,53	3,76	2,31	7,67	10,39
" 0.005 to 0.001	3,59	0.18	8,37	2,09	8,49	8,44
" 0.001 to 0.0005	0,09	1,98	0,94	0,54	1,04	0,29
smaller than 0.0005	2,51	1,06	4,79	3,40	4,97	5,26
—	100,0	100,0	100,0	100,0	100,0	100,0

[1]Stations 306, 236, 147, 258, 210 and 216 were analyzed by L. A. Iastrebova (1948), stations 1060 and K824 by M. A. Viselkina, 1893 by V. M. Ratynskiy, 371 by M. V. Klenova, K794 - the coarse fragments by I. K. Ivilov, colloidal fragments - by G. M. Ponomareva.

[2]Summation was obtained from the magnitudes of fragments ranging from 0.05 to 0.01 mm, which was based on the pipette method of weighing, and ranging from 0.01 to 0.05 mm, based on the method of difference. According to methodological research (M. V. Klenova and K. A. Rachovskaia, 1933), the numbers obtained for the fragments by the use of the pipette method are most inaccurate.

Stations	210, 127 m	216, 117 m	K824, 422 m					373[3] 181 m	K794[4], 231 m
Thickness in cm	Lower layer		1 to 3	11	20	30	40	Upper layer	
Quantity of fractions smaller than 0.01 mm by the method of elutriation in percentages	39,6	32,8	41,6	47,3	44,5	46,2	40,0	43,4	35,4
Fragments in mm:									
greater than 1	(0,63)	(0,92)	(0,01)	(0,11)	No	(0,22)	No	No	Traces
from 1 to 0.1	4,91	6,74	1,18	1,42	0,58	3,68	1,24	8,86	2,0
" 0.1 to 0.01	44,50	51,84	50,10	46,71	39,85	47,74	45,20	36,39[5]	62,6
" 0.01 to 0.005	9,66	5,08	13,81	9,05	15,74	10,93	14,25	34,59	21,20
" 0.005 to 0.001	16,56	20,67	20,95	23,29	25,38	20,64	22,78		
" 0.001 to 0.0005	7,41	4,11	4,92	7,76	6,51	11,12	6,86	11,32[6]	8,5[7]
smaller than 0.0005	16,96	11,56	9,04	11,77	11,94	5,89	9,67	8,84[8]	5,7[9]
—	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

[3] Division has been done by lengthy elutriation with a view accumulating tiny particles for their further investigation.

[4] The analysis has been computed from the usual mechanical analysis by means of elutriation controlled by the microscope and the quantitative elimination of subcolloidal and colloidal fragments by centrifugation after the preliminary elimination of carbonates, salts and absorbed bases.

[5] The sum of fragments ranging from 0.05 to 0.01 mm and determined by means of weights, and from 0.1 to 0.05 mm computed from the difference.

[6] Fragments from 0.001 to 0.0001 mm

[7] Fragments from 0.001 to 0.0002 mm

[8] Fragments smaller than 0.0001 mm

Fragments smaller than 0.0002 mm

Table 18

COMPOSITION OF FRAGMENTS SMALLER THAN 0.01 MM IN THE BARENTS SEA (COMPUTATION)

I. The Upper Layer of Cores

Stations	306	236	147	258	1060	1893	371	K824	K794
Depth in m	214	212	160	129	269	197	181	422	231
Quantity of fragments smaller than 0.01 mm by the method of elutriation	9,3	9,9	11,1	11,4	17,7	22,2	43,4	41,6	35,4
Fragments in mm:									
from 0.01 to 0.005	38,3	67,0	21,0	27,8	34,6	42,9	63,2	28,4	59,9
" 0.005 to 0.001	35,8	1,8	46,9	25,1	38,3	34,7		43,0	
" 0.001 to 0.0005	0,9	20,3	5,3	6,4	4,7	0,8	20,7[1]	10,1	24,0[2]
smaller than 0.0005	25,0	10,9	26,8	40,7	22,4	21,6	16,1[3]	18,5	16,1[4]
Quantity of fragments smaller than 0.01 mm by the pipette method	10,04	9,75	17,86	8,34	22,17	24,38	54,75[5]	48,72	35,4[6]

[1] Fragments from 0.001 to 0.0001 mm

[2] Fragments from 0.001 to 0.0002 mm

[3] Fragments smaller than 0.0001 mm

[4] Fragments smaller than 0.0002 mm

[5] Sum of fragments obtained by lengthy elutriation

[6] Fragments smaller than 0.01 mm, obtained by analysis on the basis of the method of elutriation controlled by the microscope.

II. The Lower Layer of Cores

Stations	210	216	K824			
Depth in m	127	117	422			
Thickness in cm	—	—	11	20	30	40
Quantity of fragments smaller than 0.01 mm by the method of elutriation	39,6	32,8	47,3	44,5	46,2	40,0
Fragments in mm:						
from 0.01 to 0.005	19,1	12,3	17,5	26,4	22,4	26,6
" 0.005 to 0.001	32,7	50,2	44,8	42,5	42,5	42,5
" 0.001 to 0.0005	14,7	10,0	14,9	10,9	22,9	12,8
smaller than 0.0005	33,5	27,5	22,8	20,2	12,2	18,1
Quantity of fragments smaller than 0.01 mm by the pipette method	50,59	41,42	51,87	59,57	48,58	53,56

in accordance with a definite pattern in the content of smaller fragments. With a decrease in the size of fragments, in line with the general increase in the quantity of small fragments, the quantity of each of the components increases considerably, which leads to the coordination of changes in the quantity, for instance fragments smaller than 0.01 mm and smaller than 0.001 mm (L. A. Iastrebova-Lidova, 1948) or the colloidal and subcolloidal fractions ranging from 0.001 to 0.0002 and smaller than 0.0002 mm (M. V. Klenova, 1945, 1948).

In small fragments particles from 0.01 to 0.001 mm prevail, which is especially well pronounced when converted to a 100 per cent sum of fragments smaller than 0.01 mm. As could be expected by the conversion, there is much in common in the composition of the small fragments found in various areas of the Barents Sea and in various types of sediments (table 18).

Occasional deviations are probably associated with inaccuracies of the pipette method. It is possible that the increase in the quantity of fragments smaller than 0.0005 mm in almost all of the analyses can be explained by the presence of salts, which, despite their small weight, leads to a relatively great error in the determination of their quantity. The predominance of small fragments ranging from 0.01 to 0.001 mm is also underscored by investigations of the mechanical composition of suspended particles in the Barents Sea (M. V. Klenova, 1952) and corresponds completely to the observations of Gripenberg (1934), that the suspended particles coagulate primarily to this size at normal salinity conditions.

Table 18 brings to our attention the great similarity in the composition of the small fragments of underlying layers of the core sample K824, which also is very uniform according to the data of the usual mechanical analysis. Though the data concerning the composition of the small fragments supplement our concept of the mechanical composition of sediments in the Barents Sea, they do not add anything to our understanding of the rules which we succeeded in determining by studying the mechanical composition of sediments by means of the standard method. Later we shall see how the rules become manifest in the composition (mineral and chemical) of sediments.

Chapter VIII

STRATIFICATION OF SEDIMENTS IN THE BARENTS SEA

The first sediment investigators of the northern seas, including the Barents Sea, (Schmalck, Boggild, Thoulet) noted the peculiar stratification characterised by the fact that the pink upper layer is underlain by a greenish-gray or gray sediment.

Before the Soviet investigations no other changes in the sediment composition by cores were mentioned in literature, because no core samples had been taken.

It was the Marine Scientific Institute (Ja. V. Samoilov and M. V. Klenova, 1927) that launched the mechanical analysis by layers, mineralogical examination of individual fragments and the summation of mineral types by microsections from coarse silt particles for a number of cores not longer than 37 cm. The investigation of core samples demonstrated that, with the variation of mechanical composition, an enrichment of sediments with stable components and a decrease of the quantity of unstable ones takes place in the direction of small particles. This permitted us to draw a conclusion that the mechanical and mineralogical compositions are in close interrelation with each other. A variation with depth was supposedly associated with the history of the Barents Sea in the Post-Pleiocene era and, in particular, with the transgression preceding the contemporary period of sedimentation.

During the first expeditions on the survey ship Persei (Persey), the investigators noted not only changes in the color but also in the composition of sediments, and in a number of cores taken from the southern part of the sea, the greenish-gray upper layer of sand and muddy sand was underlain by a gray and rosy-gray mud (T. I. Gorshkova, 1931). The presence of a thin layer of sand on the surface underlain by clay-like sediments was also known to the captains of commercial trawlers. On the first commercial bottom charts of the Barents Sea the information was generalized as outcrops of clay occurring in situ (M. V. Klenova, 1931, 1938). The presence of gray clay under a thin layer of the Recent sediment or directly on the bottom of the underwater slope along the coast of Norway was already pointed out by F. Nansen (1904). O. Holtedahl (1929) ascribed this to morainal origin. On the Murman Coast (Murmanskiy bereg) the sediments of the Post-Glacial transgression (see page 32) were represented by gray and bluish-gray clay.

V. P. Zenkovich and P. S. Vinogradova (1935) described the contact between the Recent greenish-gray sediments and the old bluish-gray sediments (blue clay) in the coastal area of the Barents Sea between the Rybachiy Peninsula (poluostrov Rybachiy) and the Kil'din Island (ostrov Kil'din). Most frequently the contact was uneven, frequently individual lumps of the blue clay were enclosed in the layer of the greenish-gray sediments, but the few centimeters of the upper bluish-gray sediments consisted of one or two sandy interlayers. In several cores the investigators observed a thin /311
broken interlayer consisting of gravel and coarse sand at the interface

of two sediment types. On the basis of an investigation of the mechanical composition of the cores E. K. Kopylova (M. V. Klenova, 1938) was able to find in a number of samples taken from the Barents Sea that between the surface layer of sand sediments and the more clayey lower layer lies an intermediate stratum representing a mixture of the two sediments and forming a two-apex graph of mechanical composition.

In contrast to the Recent greenish-gray layers of the southern portion of the Barents Sea, the gray and bluish-gray, more or less clayey, sediments are devoid of chlorophyll (L. A. Iastrebova, 1938). They contain more carbonates than the Recent sediments, effervesce slightly when treated with acids, contain less organic carbon, but the colloidal fragments (from 1 to 0.1 m) contain more aluminium, calcium and less magnesium and alkali than the Recent sediments (M. A. Rateev, 1948).

Roentgenographic analysis of a sample of the old clay taken from the Murman Shoal (Murmanskoya melkovod'ye) showed the presence of kaolin together with hydro-mica (M. A. Rateev, 1948), whereas the Recent sediments of the same area contained only hydro-mica of the numerous clay minerals. This was confirmed also by the method of dyeing (see page 264). The old bluish-gray sediments also differ from the Recent sediments by a number of other characteristics. L. A. Iastrebova (1948) mentions their greater weight (density) and smaller porosity, greater elasticity and viscosity, a higher degree of cohesion and internal friction in comparison to the Recent sediments. Thus it could be assumed that the underlying Recent sediments having a bluish-gray or gray color and being more or less clay-like have

been formed in different physical-geographical conditions in comparison with the other Recent sediments. However, as we shall later see, it could not be asserted that throughout the entire expanse of the Barents Sea they have one and the same Post-Glacial age.

All these data call for a detailed description of the core samples obtained from the Barents Sea by means of splitting them in a dry condition. In the fresh cracks of dry cores it is possible to notice characteristics of sediment stratification which escape the attention of an observer when examining moist cores and which become soiled from sawing (E. K. Kopylova, 1937) and cutting. In this way we examined 712 core samples from 7 to 110 cm long and several longer cores 122, 137 and 184 cm long. A very interesting characteristic of the stratification of the Barents Sea cores was an almost ubiquitous presence of sandy coatings found in the form of spots whose thickness sometimes reached 1 to 2 cm, but which were usually negligible, When dried, the cores become divided along these coatings and spots into individual segments. In a number of cores, the quantity of these coatings was very great; when dried, and more so when split, the respective core became divided into a number of disks consisting of a more muddy material. The arrangement of the coatings and spots is not irregular, but they form pronounced layers. Thus one of the favorite layers found in almost all of the cores is located at approximately the 10-cm mark of each of the cores. In most instances the coatings are observed between the 7 to 12-cm marks. Frequently such spots occur between the 17 to 22-cm marks, on the average at the 20-cm mark. In longer cores one can find such

coatings at the 30 to 35-cm marks. Regrettably, the cores at our disposal are not very long, but, evidently, in accumulation areas such sand coatings are also preserved in deeper layers.

The sediment stratification is expressed by several means. In addition to the mentioned sand coatings and spots, along which the cores can be readily divided into separate segments, at places one can observe clay spots in natural cracks of dry cores, which sometimes includes shells. The position of the coatings of two cores obtained from adjacent localities usually coincides, and thus they indicate changes in the conditions of /312 sedimentation. Sometimes also changes in the mechanical composition of sediments occur abruptly. In such cases, most frequently in a dry condition, the respective core becomes divided along the clay coating or spot.

The coatings or interlayers of sesquioxides are a very characteristic feature of stratification. Sometimes they separate the pink upper layer from the gray or greenish-gray lower layer, and the most clearly pronounced change in deoxidation conditions occurs in these interlayers (A. V. Trofimov, 1939). Iron evidently falls out from the interlayers in the form of stable oxides which are preserved in the restoration medium of the lower layers of cores. M. M. Ermolaev (1948) assumes that the ferrous interlayers of the cores obtained from the northern part of the Kara Sea (Karskoye more) correspond to the periods marked by an active impact of the Atlantic waters, i.e. to the warming up of the climate. This assumption, however, requires an additional verification. The ferrous layers frequently do not contain calcareous rhizopods which are brought by the Atlantic water and are found in

great quant.ties in the restored greenish-gray and bluish-gray layers.

Meanwhile in the sediments of the Arctic Basin (V. M. Saks, N. A. Belov and others, 1955) the pink interlayers in comparison with the bluish-gray layers, are considerably enriched with the Atlantic forms of rhizopods. Obviously, the gray sediments underlying the pink Recent sediments in various layers of the Arctic Basin and its marginal seas are of a different age.

The ferrous interlayers representing the old weathered strata are frequently found at the interface between the present day sediments and the older underlying layers. From our point of view, they do not manifest simply a change in the hydrological regime but they do manifest more serious changes connected with the formation of relief elements and depth variations, including the arrangement of individual morphological elements of the sea. In local areas marked by a retarded sedimentation and partly by washouts, a stable oxidized layer is formed which, when buried by sediments, is preserved in the form of an old weathered layer.

In order to interpret the vast collected material concerning the structure of cores (2233 measurements), the frequency by percentages of individual layers with respect to the number of measurements of the thickness of layers and their position was computed for each area. Thus the most frequently occurring positions of layers were clarified, on the basis of which a peculiar rhythm was detected; it is well pronounced in the upper 30-cm of cores and slightly less pronounced in the deeper strata. This

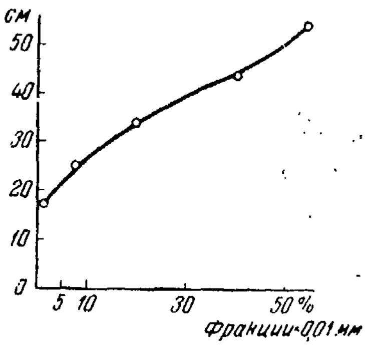

Fig. 122.

Length of Cores in Connection with Mechanical Composition

Key. Lower right-hand section:

Fragments smaller than 0.01 mm

is explained by the fact that a much greater number of data is available for the upper layers than for the lower ones, because the number of cores exceeding 30 to 40-cm is small. In the determination of the position of individual strata we shall utilize all of their types: the sand spots, cleavages along the clay coatings, ferrous interlayers, abrupt changes in the mechanical composition, etc. For certain areas the length of core can also indicate changes in the conditions of sedimentation. A direct cause for a short core is the vertical variation in the density of sediments. When working with the same bottom corer, the length of cores differs in accordance with the mechanical composition of the sediment (fig. 122), and

the depth reached by the corer in the bottom can to a certain degree be considered as an indicator of the overall thickness of sediments by the vertical (table 68).

Table 68

LENGTH OF CORES IN CONNECTION WITH THE MECHANICAL COMPOSITION OF THE UPPER SEDIMENT LAYER (MEAN DATA)[1]

Type of sediment	Number of cores	Mean length of cores in cm
Sand	20	19,0
Muddy Sand	25	25,3
Sandy Mud	125	34,1
Mud	140	44,1
Clayey Mud	15	53,8

[1]The cores were obtained by the GOIN type of corer, weighing 16 kg, and differing from the usual Eckman corer by the presence of an internal brass axle which opens the core lengthwise, permitting one to obtain undisturbed samples.

The structure of the Barents Sea floor by areas was described earlier (see Chapter V). Here we shall discuss only the general characteristics of stratification, the character and position of interfaces and the variation in the mechanical composition of sediments, which are based on 1050 cores analyses, and list the data of micro-Paleontological identifications.

1. The Nordkapp Trench

The stratification in the Nordkapp Trench was interpreted on the basis of 10 cores whose maximum length was 76 cm. Here one can distinguish two types of stratification. In the western part of the trench, the change in the mechanical composition of sediments occurs gradually (St. 1877, 252 m; St. 2786, 290 m). Sometimes also the color shade changes gradually (St. 1070, 240 m). In the eastern part of the area, the sandy mud layer is underlain by a rosy-gray and gray clay separating the layer by an abrupt and frequently uneven boundary from the upper layer. In the cores one can distinguish sandy interlayers and spots at the same depth levels. The small difference in the position of the layers is explained by differences in the rate of sedimentation, which at St. 2786 (nearer to the continent) is greater than at St. 1070. Thus the layer at the 5-cm mark of the core at St. 1070 corresponds to the layer at the 8-cm mark of the core at St. 2786; the 10-cm mark corresponds to the 32-cm mark, the 38-cm mark to the 39-cm mark, the 48-cm mark to the 52-cm mark. The sand spot observed at the 46-cm mark of a core obtained at St. 2786 does not have its counterpart at St. 1070, but the respective depth of 62 to 64 cm has not been reached by the corer since the length of the core is 49 cm. In the eastern portion the discontinuous layers can be well compared to each other if they are examined separately for the upper Recent layer and for the lower older layer of sediments.

The curve characterizing the frequency of occurrence (fig. 123) has several convexities corresponding to the interfaces that occur most frequently, on the average at the 3, 5, 10, 15, 17, 22, 26, 32 and 38-cm marks. The presence of coinciding depth level marks in the lower layers of the cores may indicate the fact that the intermediate layer lying between the underlying gray clay and the upper greenish-gray sediment had been formed in situ during the washout processes of the upper clay layer, in any case, without its reaching the surface. The data from stations exceeding 200 m in depth make the assumption very probable.

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The cores, in which vertical changes in the composition occur gradually (fig. 124), pertain to areas characterized by a more or less intense accumulation process (Stations 2672, 1070, 1877 and 2786). Abrupt changes in the mechanical composition are observed in cores characterized by a thin layer of contemporary sediments (Stations 1534 and 2673).

2. The Murman Underwater Slope

The 31 sample cores, 10 to 54 cm long, which were obtained from the Murman Underwater Slope have been thoroughly examined. Most frequently the stratification is characterized by abrupt replacement of the upper greenish-gray sand or muddy sand by gray or rosy-gray mud (clay). Sometimes one can observe sand spots at the 10 to 12-cm marks of cores; at St. 666 this coating appears to form an interface beneath which a thin interlayer of greenish-gray sandy mud and gray mud was observed, whereby at a distance of about 20 cm, not less than 8 pairs of interstrata occurred.[1]

[1]The determination of minerals by dyeing yielded gypseous schist for the upper and lower layers of the sample core obtained at St. 666, but in the bright interlayer an admixture of beidellite was observed.

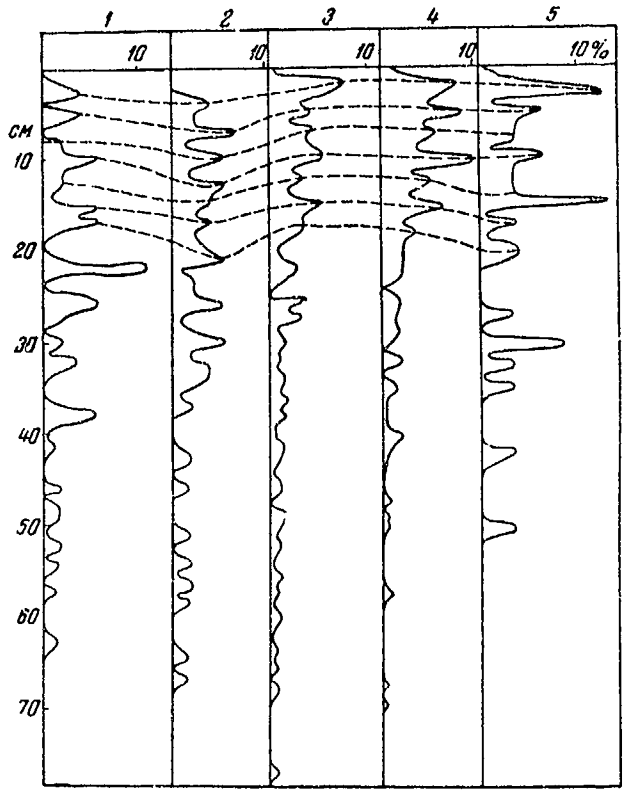

Fig. 123. Curve showing the frequency of layer occurrence.

1 -- the Nordkapp area; 2 -- the area of the Western Commercial Banks (Zapadnyye promyslovyye banki); 3 -- the Bear or Western (Medvezhinskiy) Trench; 4 -- the Bear (Medvezhinskaya banka) Bank; 5 -- the underwater slope of Spitsbergen.

The cores that have not penetrated the Recent sediments are expressed by curves in which the frequency of occurrence is marked by convexities at the 5 to 7, 10 to 11, 14 and 20 to 21-cm marks, but the longer cores have the convexities at the 30 and 41 to 42-cm marks (fig. 125).

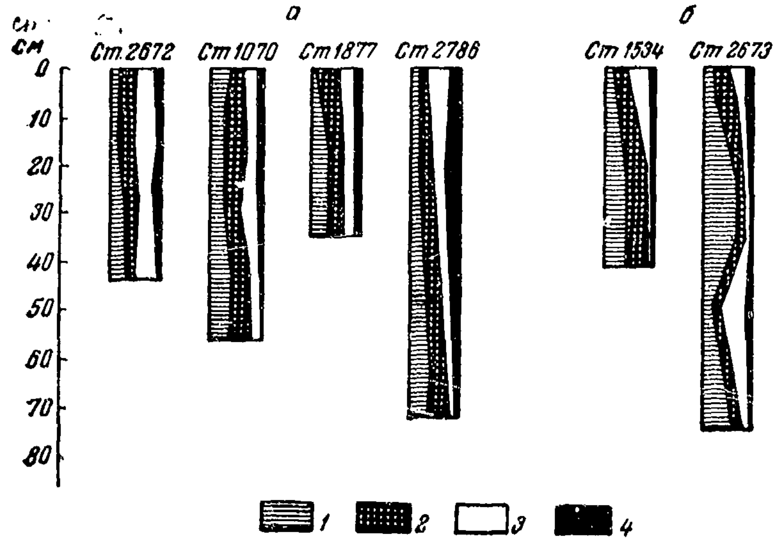

Fig. 124. Stratification types by the mechanical composition of sediments.

a -- areas of intensive accumulation (Stations 2672, 1070, 1877 and 2786);

б -- areas marked by a small thickness of contemporary sediments (Stations 1534 and 2673).

(Symbols are explained in fig. 127.)

In front of the entrance to the Kola (Kol'skiy zaliv) and Motovski (Motovskiy zaliv) Gulfs, the old blue clay reaches the surface of the bottom in the area marked by washouts at the foothill of the slope, but with an increase in depth its surface sinks and the thickness of Recent sediment increases (V. P. Zenkovich and P. S. Vinogradova, 1935).

As in the case of the Nordkapp Trench area, changes in mechanical composition occur gradually in areas characterized by accumulation (St. 2128, for instance), but in places where the old sediments are found near the surface of the bottom, the changes occur abruptly (fig. 126; Stations 677 and 1072). It could be remarked that at shallower depths (143 and 161 m) to the north of the Kil'din Island (ostrov Kil'din) a more fine-grained material has been found in the underlying layer than is the case at greater depths at the entrance to the Motovski Gulf (Motovskiy zaliv) and to the north of the Rybachiy Peninsula (poluostrov Rybachiy) (St. 663, 210 m). In the lower layer of a core obtained at St. 2128, N. A. Voloshinova discovered few Cibicides refulgens Montf.

3. Pre-Kanin Area

A detailed examination of 14 cores from 12 to 38 cm long obtained in the Pre-Kanin area shows that the underlying layers have not been reached. Accumulation predominates in the area; changes in mechanical composition occur gradually and the boundary areas are not clearly marked. Sometimes one can observe a slight enrichment of minute particles at the 15 to 16-cm marks of cores, but toward the bottom the sediment becomes similar to the upper layer or a little more sandy (fig. 127).

4. The Kanin-Kolguyev Shoal
(Kaninsko-Kolguyevskoye melkovod'ye)

The cores from the Kanin-Kolguyev Shoal have a similar character. Out of the 19 cores, from 12 to 22 cm long, only 6 cores disclose the bordering

layers, and they are weakly pronounced. Deeper in the bottom, the quantity of fragments that are smaller than 0.01 mm increase somewhat, but the type of mechanical composition does not change.

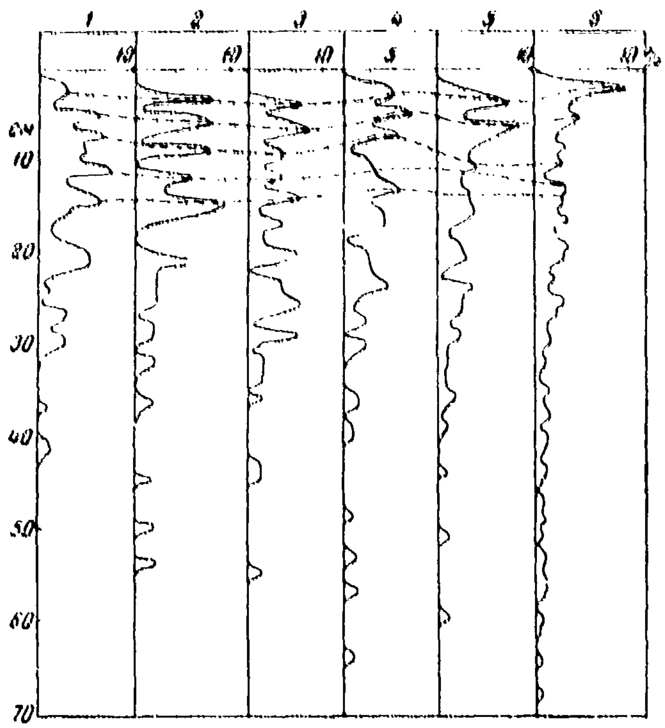

Fig. 125. Curve showing the frequency of occurrence of interfaces in cores by areas.

1 -- the Murman Shoal; 2 -- the Murman Bank; 3 -- the Central Plateau; 4 -- the Central Elevation; 5 -- the Persey Elevation; 6 -- the Northern Plateau.

5. The Nu.man Bank
(Nurmanskaya Banka)

In the eastern portion of the Nurman Bank, the cores reflecting the Recent period of sedimentation (Stations 1077, 749, 247, 1078 and 255), can be compared with the cores obtained from the Kanin-Kolguyev Shoal. Everywhere along the Kola Meridian, at longitudes 35 and 38° E, the Recent greenish-gray sand or sandy mud is underlain by older deposits at the 9, 12 and 25-cm marks of the cores and so on. Sometimes one can observe interstratification at boundary layers; in some instances, admixture of sand with gravel is found (St. 1535, cores 1 and 2).

N. A. Voloshinova, examining the cores obtained from the northwestern spur of the Murman Bank (St. 1535), disclosed at the 6 to 9-cm marks of the Recent greenish-gray sandy mud Nonion umbilicatulum Montagu, var. pacifica Cushman — 1; Cibicides refulgens Montf. — 1; at the 35 to 39-cm marks of the underlying rosy-gray mud layer, Cassidulina nocrossi Cushman and radiolaria, but at the bottom of the core in the lower layer of greenish-gray sandy mud (at the 60 to 63-cm marks) Nonion umbilicatulum Montagu, var. pacifica Cushman — 1; Cassidulina laevigata Orb., var. carinata Cushman — 1; Globigerina — 1; Cibicides sp. — 3.

6. Area of the Western Commercial Banks

(Zapadnyye promyslovyye banki)

This area with its complex bottom relief must be assigned to erosion areas. However, accumulation does occur here to a small degree, but, due to great depths, the process is considerably smaller than in shoaling areas.

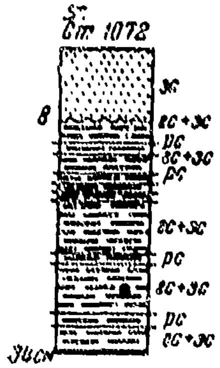

Fig. 126. Stratification in the eastern portion of the Nordkapp Trench — a core at St. 1072. (Symbols are explained in fig. 46.)

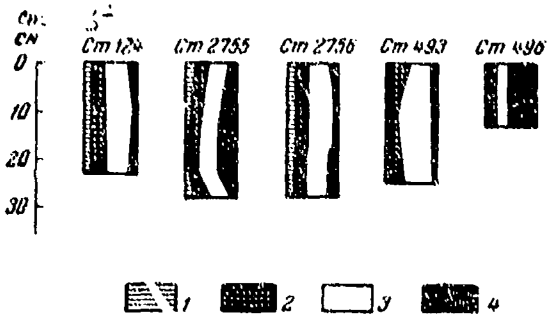

Fig. 127. Changes in the mechanical composition based on the cores obtained from the Pre-Kanin area.
1--fragments smaller than 0.01 mm; 2--from 0.01 to 0.05 mm; 3--from 0.05 to 0.1 mm; 4--0.1 to 1 mm.

Almost everywhere along the Cape Nordkapp-Bear Island (Bjørnøya) cross section, the upper layer of the Recent sandy mud having a yellowish-gray or greenish-gray color is underlain by a gray (sometimes rosy-gray) sediment with gravel (fig. 128), in some cases with shingle, which characterizes a period of retardation of sedimentation in the past (St. 1137, core 2; St. 2365, St. 1138, etc.).

The curve showing the frequency of occurrence (fig. 123) in the area of the Western Commercial Banks is marked by convexities at the 4, 7, 10, 13, 17, 21, 2[illegible] 30 and 33-cm marks of cores. Changes in mechanical composition along the Cape Nordkapp-Bear Island (Bjørnøya) cross section occur mainly without abrupt stages (fig. 129) as the number of fragments smaller than 0.01 mm gradually increases toward the bottom of the cores. Only at the 30-cm mark (Stations 1137, 1138 and 1139) and sometimes slightly higher (Stations 1879 and 2787) a more abrupt discontinuity, i.e. the appearance of mud in the form of a more or less thick interlayer, is observed in the cores whose upper sections contain sandy mud. This mud has, as a rule, light-gray color and contains carbonate remains so that it effervesces when treated with hydrochloric acid. Sometimes it has a slight rosy-color or yellowish hue.

N. A. Voloshinova found at the 32 to 34-cm marks of cores (St. 1137) obtained to the north of Cape Nordkapp: Globigerina, Cassidulina laevigata Orb., var. carinata Cushman — 2; C. nocrossi Cushman — 3; Cibicides refulgens Montf. — 5; Nonion umbilicatulum Montagu, var. pacifica Cushman — 2; Elphidium incertum (Williamson), var. clavatum Cushman — 2; Angulogerina angulosa Williamson — 1.

Fig. 128. Sediment stratification along the Cape Nordkapp-Bear Island (Bjørnøya) cross section in the area of the Western Commercial Banks (Zapadnyye promyslovyye banki) (St. 1138, 282 m; from the 11 to 32-cm marks of the second core). The yellowish-gray sandy mud lies on a rough surface of gray mud with gravel at the 27-cm mark of the core.

7. The Pechora Shoal

(Pechorskoye melkovod'ye)

At the 8 to 32-cm marks of cores obtained from the Pechora Shoal — which is a typical deposit — one can observe only slight traces of interruptions in sedimentation and a retarded process of it. As was pointed out before (Ia. V. Samoilov and M. V. Klenova, 1927), the lower layers of the major part of the cores contain a coarse-grained sediment. In the area of the Khaypuyrskaya Guba, on the contrary, the lower layers contain more fine-grained material, while preserving the general character of the mechanical composition.

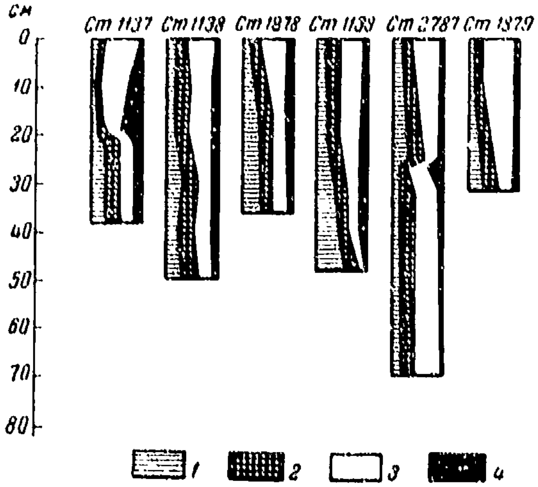

Fig. 129. Changes in the mechanical composition of sediments from cores on the Cape Nordkapp-Bear Island (Bjørnøya) cross section.

(Symbols are explained in fig. 127).

In the Khaypudyrskaya Guba (St. 388) N. A. Voloshinova identified: Nonion umbilicatulum Montagu, var. pacifica Cushman — 2; Astrononion stellatum Cushman et Edwards, by single specimens, Elphidium sp. — 1; Angulogerina angulosa Williamson — 1; Eponides sp. — 2.

8. The Goose Bank
(Gusinaya Banka)

The cores obtained from the Goose Bank (15 cores 10 to 56 cm long) pertain only to Recent sedimentation. This is manifest by the considerable stability of the stratification of interfaces. They almost coincide in the first and second cores (fig. 130) obtained from the adjacent areas, for instance at St. 775 (190 m) and along the southern slope of the Goose Bank. At greater depths (St. 2610, 212 m and St. 1112, 288 m), i.e. in areas marked by intensified accumulation, the interfaces are displaced toward the bottom of the cores, which attests to an accelerated accumulation of sediments. The presence of the displacement confirms the r sumption that the material taken from the surface of the Goose Bank is deposited at the foothills of the slopes. At shallower depths (St. 2505, 146 m and St. 2509, 161 m) one can observe a displacement in the reverse direction, i.e. the sedimentation occurs at a slower rate. As a result of a small number of measurements, the curve of frequency occurrence did not present a well defined pattern (fig. 131).

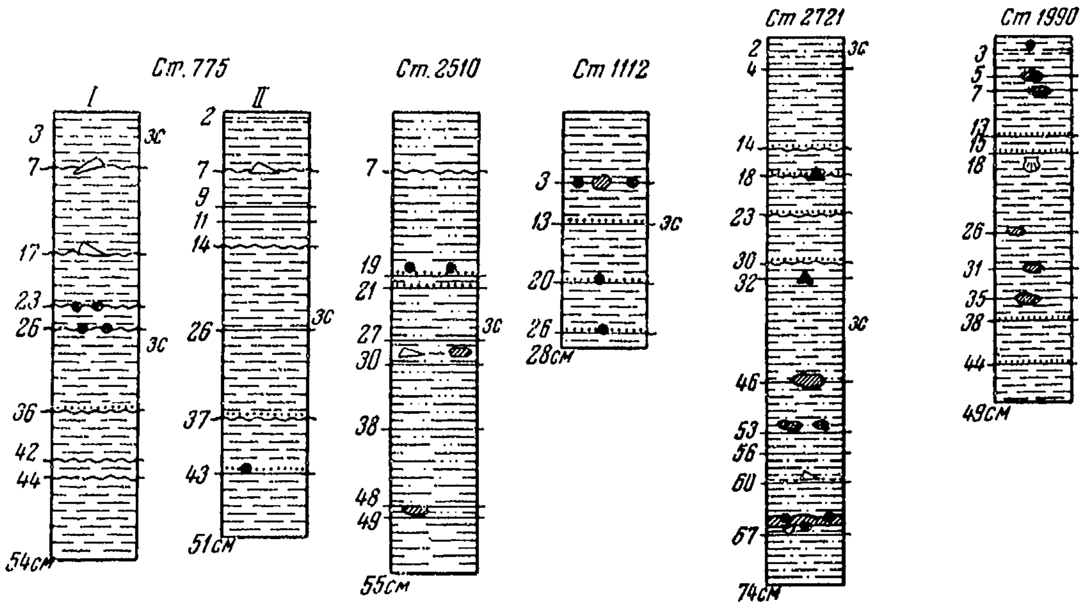

Fig. 130. Interfaces, i.e. sand interlayers in cores.

1 — St. 755, 190 m; St. 2510, 212 m; St. 1112, 288 m; 2 — St. 2721, 140 m; St. 1990, 225 m.

(Symbols are explained in fig. 46)

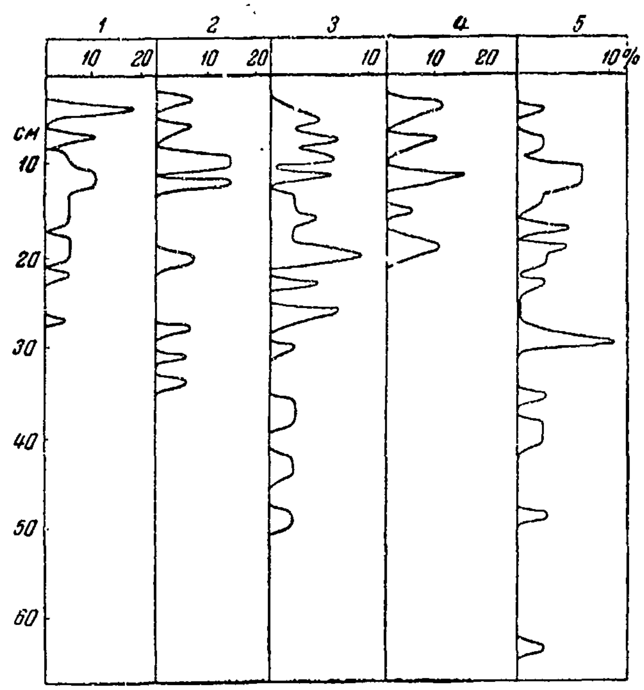

Fig. 131. Curve of the frequency occurrence of interfaces in cores by areas.

1 -- Pre-Kanin area; 2 -- the Kanin-Kolguyev Shoal; 3 -- the Goose Bank (Gusinaya banka); 4 -- the Pechora Shoal; 5 -- slopes of the southern island of Novaya Zemlya.

Microfaunal analysis of sediments on the Goose Bank (Gusinaya banka) (St. 239) indicated the presence of the following organisms from 2 to 4-cm in the cores: Haplophragmoides subglobosa (Sars) — 2; Cassidulina crassa Orb. — usually; C. laevigata Orb., var. carinata Cushman — seldom; Cass. nocrossi Cushman — 1; Cibicides sp. — seldom; Cibicides refulgens Montf. — seldom (N. A. Voloshinova), but at St. 2510 from 4 to 8-cm; Haplophragmiodes sp. indet. — 1; Reophax scorpiurus Montf. — 1; Eponides sp. — 1; Cibicides refulgens Montf. — by single specimens; Cibicides sp. — by single specimens. In the lower layer of the core, from 53 to 55-cm, the fauna was not observed.

9. The Central Plateau

(Tsenral'noye Plato)

Almost all of the cores in the area of the Central Plateau, as in the more southern areas, such as the Murman Bank and the Murman Shoal, had reached the underlying layers, which characterizes the area of the Central Plateau as an area of slow sedimentation and of thinnessof the Recent sediments.

The cores at Stations 1062 and 1060 on the slopes of a small bank having a negligible thickness of Recent sediments demonstrated that the sandy mud at St. 1060 is being deposited at a more rapid rate than the muddy sand at St. 1062. This agrees well with the position of the Nordkapp Current which flows along the northern slope of the Murman Bank.

The major part of the cores are characterized by abrupt changes in mechanical composition. The sandy mud of the upper layer is replaced by mud and later by clayey mud. While on the Murman Bank one can observe a sharp transition from muddy sand or sandy mud to clayey mud, on the Central Plateau the underlying layer is for the most part represented by mud, which sometimes in deeper layers (for instance, at St. 1060) is replaced by clayey mud. This clayey mud, in contrast to the southern areas, is more viscous, considerably carbonaceous and less saline.

10. Slopes of the Southern Island of Novaya Zemlya

The cores (all together 11) in the area of the slopes of the southern island of Novaya Zemlya, 11 to 65 cm long, pertain primarily to the Novaya Zemlya Trench (Novozemel'skiy zhelob) and, in connection with it, they disclose only the Recent period of sedimentation. The boundary layers are expressed by cleavages along the clay patches and, less frequently, along the sand spots. The layer from 10 to 12-cm is most clearly pronounced. Further, the cleavages at St. 370 (185 m), St. 371 (181 m) and St. 372 (185 m), i.e. at the maximum depths, are located somewhat higher than at St. 379 (120 m) and St. 830 (25 m), where the cores contain sandy mud which has evidently been deposited more rapidly.

The sediment becomes somewhat coarser with depth (Ia. V. Samoilov and M. V. Klenova, 1927), which can be observed at the deepest stations (St. 136, 175 m; St. 149, 120 m; St. 150, 140 m).

According to V. P. Zenkovich and L. A. Iastrebova (1946), along the edges of the trench the increase in the size of material occurs after an increase in the quantity of particles smaller than 0.01 mm, whereas in the central section the mechanical composition is characterized by a great stability.

11. The Northern Shoal of Novaya Zemlya

(Severnoye Novozemel'skoye melkovod'ye)

The sediment stratification of the northern shoal of Novaya Zemlya is presented by 38 cores 9 to 74 cm long. In a number of cores the layer of Recent sediments is thin. The interface between the Recent and the ancient sediments is sometimes uneven appearing as an old weathered strata, ferrous interlayers (Stations 562 and 766), enriched with gravel (St. 2723) and so on. Sometimes a mixed layer is formed (see fig. 63, Stations 1996 and /321
2725; fig. 132). The cores obtained from the Novaya Zemlya Trench, i.e. from an area characterized by intense deposition, either contain no boundary layers or they appear as clay patches and sand spots along which natural cleavages of cores occur.

When comparing the upper sections of the cores obtained from the slopes of the bank of Gorbovye Islands (ostrova Gorbovy) (St. 2721, 140/201 m) with those obtained from the Novaya Zemlya Trench (St. 1990, 225 m), it can be seen that the boundary layers are displaced toward the side characterized by an increase in thickness, i.e. by a more rapid rate of sedimentation at St. 1990 (fig. 130).

In depositional areas changes in the mechanical composition of sediments occur gradually. The underlying layer of the northern section of the area is represented by clayey mud having a partly rosy-gray color (St. 562). On the elevation of Gorbovye Islands (ostrova Gorbovy) (St. 2719) the Recent sandy mud layer is underlain by mud, also having a slightly rosy-gray color, with an admixture of greenish-gray rock which evidently lies beneath the erosion products, as in the case of St. 2725 (fig. 132).

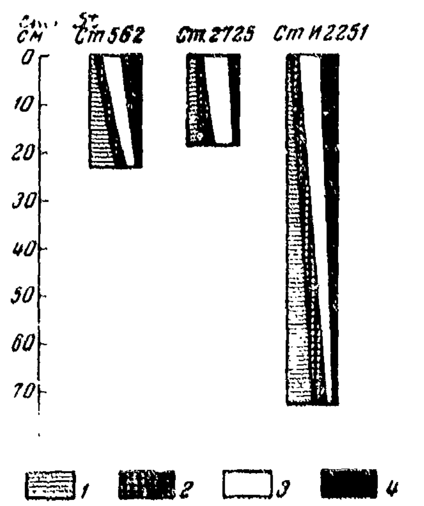

Fig. 132. Changes in the mechanical composition of sediments as shown by the cores taken from the northern shoal of Novaya Zemlya at St. 562, 76 m; St. 2725, 157 m; St. I2251, 157 m. Symbols are explained in fig. 127.

On the bank of Gorbovye Islands (ostrova Gorbovy), the upper layer of cores (St. 2725) does not contain fauna, but the lower layer (from 15 to 19-cm) consisting of gray mud contains Cibicides refulgens Montf. — 3; Cibicides sp. — 3 (N. A. Voloshinova). N. A. Voloshinova, examining the gray sandy mud obtained from the Novaya Zemlya Bank (St. 766), found that the layer from 18 to 23 cm contained sandy rhizopods which were not well preserved, as well as Lagena marginata (Walker et Jacob) — 1; Cassidulina crassa Orb. — 1; C. Laevigata Orb., var. carinata Cushman — 1; Pullenia bulloides Orb. — 1; Cibicides refulgens Montf., Cibicides sp. — seldom, of which Pullenia bulloides is of interest since it reflects the effect of the Atlantic water. In the area where the material being eroded from the slopes

is being accumulated (St. 1274), to the north of Cape Hope (mys Zhelaniya), a rich and variegated microfauna was found from 3 to 8 cm in the cores, as for instance: Lagena sp. — many; Nonion umbilicatulum Montagu, var. pacifica Cushman — usually; Astrononion stellatum Cushman et Edwards — usually; Elphidium arcticum (Parker et Jones) — very many; Elph. incertum (Williamson), var. clavatum Cushman — many; Elphidium sp. — usually; Cassidulina crassa Orb. — many; Cassid. nocrossi Cushman — many; Globigerina Cristellaria sp. — usually; Angulogerina angulosa (Williamson) — 1; Robertina arctica — 1; Miliolina sp. — very many; Eponides karsteni (Reuss) — many; Eponides sp. — seldom; Cibicides refulgens Montf. — many; Cibicides sp. — many; Ostracoda sp. sp. — many.

12. The Central Elevation

(Tseneral'naya Vozvyshennost')

The Central Elevation is represented by 36 cores from 8 to 67 cm long collected by the survey ship Persei (Persey). Despite their short length, a number of cores show that a thin (sometimes less than 10 cm) layer of Recent sediment covers the underlying rocks. P. S. Vinogradova (1946) investigated the cores collected in 1940 from the survey ship Issledovatel' where the Recent sediment covered a greenish-gray and rosy-gray clay, /322 which was sometimes stratified. The underlying layer was frequently represented by a dark-gray mud and clay-like mud with a considerable admixture of fragmentized material at great depths — gravel and fine shingle consisting of clayey schist and calcareous rocks; at places the lower layer

had the marks of washouts from the underlying in situ rocks. Sometimes the reappearance of greenish-gray muddy sand was observed under a rosy-gray mud (St. 2469), which is probably associated with the landsliding of sediments down the steep slopes.

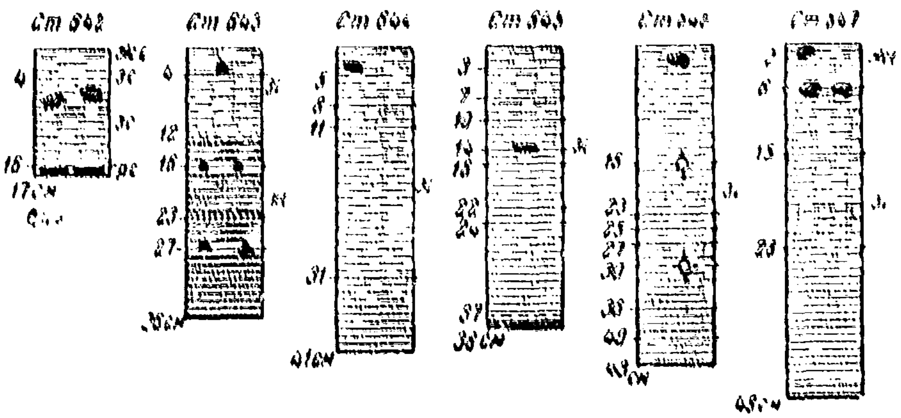

Fig. 133. Boundary layers in accumulation areas on the south of the Central Elevation: St. 642, 230 m; St. 643, 222 m; St. 644, 250 m; St. 645, 269 m; St. 646, 277 m; St. 247, 27 m. Symbols are explained in fig. 46.

In comparison with the cores obtained from the neighboring depositional areas, the boundary layers are displaced, i.e. individual layers are characterized by their thinness. Retardation of the rate of sedimentation leads to the development of a ferruginous weathering process, (and) the formation of all kinds of ocherous patches and spots. In a depression on the southern slope of the elevation — an area which is characterized by intense accumulation — the boundary layers are pronounced for a great distance (Stations 642, 643, 644 and others), as in the case of the cores taken from the southern part of the sea (fig. 133).

The mechanical composition varies little along the vertical, which testifies to rapid sedimentation and is confirmed by the distribution pattern of chlorophyll (V. P. Zenkovich and L. A. Iastrebova, 1946).

On the surface of the elevation and its southwestern spur, where the sedimentation is retarded and an abrupt change in mechanical composition occurs, the increased quantity of chlorophyll in the upper layer is replaced by a small but a very stable structure of it in the lower layers of the cores.

On the slopes of the elevation, with an increase in the thickness of Recent sediments, the mechanical composition of the underlying layer becomes finer-grained than in the same layer on the elevation itself. This indicates that during the formation of the given layer the Central Elevation was already delineated on the bottom relief of the Barents Sea.

In comparison with the Central Plateau (fig. 125), the boundary layers of the Central Elevation have been moved closer to each other.

13. The Persey Elevation

(Vozvyshennost' Perseya)

According to 49 cores from 5 to 51 cm long, the stratification of the Persey Elevation is identical to the stratification of the Central Elevation. The thickness of Recent sediments does not exceed 30 cm, and the cores disclose the underlying gray and rosy-gray layers to exist everywhere. A detailed examination of the cores indicates that the /323

coarse-grained material, which enriches the sediments on the Persey Elevation, is not associated with the melting of ice and icebergs, but the greatest enrichment is observed at places where the ancient rocks lie near the surface. The composition of boulders and their intense weathering (M. V. Klenova, 1936) makes one think of their local origin. The boundary layers recognized in the cores taken from the Persey Elevation pertain either to a change in the reoxidation processes, i.e. of the upper layer having a pink color and the lower layer having a gray or pinkish-gray color, or to the boundary between the Recent and the underlying layers.

On the southern slope of the elevation and in the central depression one can notice stratification (St. 1026), but the underlying mud — whose mechanical composition is marked by a two-apex graph — is similar to the glacial mud which is deposited on the steep slope and is similar to the sediments found in fjords (St. 1044). The gray mud, whose mechanical composition is expressed by a two-apex graph and which was found on the southeastern spur (St. 2455, 240 m) near St. 1044, forms an interlayer in the greenish-gray sandy mud (fig. 134).

In connection with changing conditions in sedimentation and in the denudation of the underlying layers, the mechanical composition of sediments changes considerably along the vertical, especially in the eastern section of the elevation (fig. 134, St. 2686).

In a number of cores the clayey mud is again underlain by a more coarse-grained material (for instance at Stations 2870, 2455 and so on).

From 22 to 24-cm in the core obtained at St. M122 in the western part of the elevation the sandy mud consisting of smooth shingles of light sandstone contains: Ammodiscus — 2; Eponides — sp. — 1; Cibicides refulgens Montf. — 2 (N. A. Voloshinova).

14. The Bear Bank

(Medvezhinskaya banka)

According to the 72 cores from 7 to 74 cm long and two cores 136 and 184 cm long, the greater part of the Bear Bank blankets the underlying layers. as in the other areas characterized by a thin cover of the underlying layers, the boundary surfaces on the curve of frequency occurrence (fig. 123) lie rather closely together and are most clearly pronounced in the upper 15 to 16 cm layers of the cores. For the most part they are represented by fractures with a slight admixture of sand, but in some cores the interstratification of a greenish-gray muddy sand and bluish-gray mud is well pronounced (for instance at St. 1898a, 300 m, at the foothills of the southern slope of the elevation).

The bluish-gray sandy mud found on the southeastern slope (Stations 1917, 1918, 1922) is characterized by a two-apex graph of the mechanical composition; at places an admixture of coarse-grained material, such as gravel, shingle and carbonate remains, is found. At greater depths the

gray underlying layer is represented by a gray clay-like mud (sometimes with a slight rosy-colored hue) in contrast to the upper layer which is devoid of microfauna.

On the southern slope of the Bear Island Bank the cores had not penetrated the Recent sediment. A gradual enrichment of the sediment with particles smaller than 0.01 mm is observed with increase in the depth to the bottom (St. 1939, 1940 and others). Among the numerous specimens of microfauna these species were observes at St. 2008, 224 m: Lagena aff. hexagona (Williamson) — 2; Langena sp. sp. — 3; Angulogerina angulosa (Williamson) /324 — many; Dentalina communis Orb. — 1; Dentalina sp. — 1; Nonion umbilicatum Montf. var. pacifica Cushman — many; Nonion labradoricum (Dawson) — seldom; Elphidium arcticum (Parker et Jones) — seldom; Elph. incertum (Williamson), var. clavatum Cushman — seldom; Elphidium sp. — seldom; Astronion stellatum — by single specimens; (Cushman et Edwards) — Cassidulina crassa Orb. — very many; Cassidulina sp. — seldom; Cass. nocrossi Cushman — many; Cass. laevigata var. carinata Cushman — usually; Pullenia bulloides Orb. — 4; Globigerina — many; Eponides karsteni (Reuss) — many; Eponides sp. sp. — many; Cibicides refulgens Montf. — many; Cibicides sp. sp. — very many (N. A. Voloshinova).

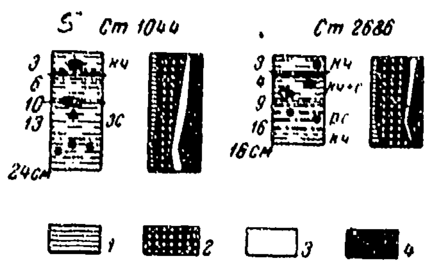

Fig. 134. Stratification on the Persey Elevation (St. 1044, 200 m; St. 2686, 159 m) and changes in mechanical composition. Symbols are explained in fig. 46 and 127.

When examining the distribution of the lower sediment layer on the south-eastern slope of the Bear Island Bank, one can see that an increase in depth in the direction of the Bear Island Trench (Medvezhinskiy zhelob), increases the quantity of minute particles not only in the upper layer, as has already been pointed out, but also in the underlying layer. This attests to the preservation of the overall character of bottom relief during the sedimentation of the gray deposits. One can, however, note at the same time that the amplitude of variation in the mechanical composition of lower layers is smaller than in the upper layers. In addition, the bottom section of cores does not contain muddy sand which is widely represented in the surface layer, even at great depths. It could be concluded that, with the preservation of the overall character of the bottom relief, it was considerably softer and the hydrodynamical regime, connected with the present day current system, bore a more active character.

15. The Underwater Slope of Spitsbergen

On the underwater slope of Spitsbergen we had studied 23 cores from 9 to 137 cm long. At great depths the cores disclosed very stable boundary surfaces (St. 2852, 438 m; St. 2853, 411 m; St. 2857, 424 m).

In connection with rapid sedimentation, variations in the mechanical composition along the vertical are comparatively small; the general sediment type is preserved from the top to the bottom. Only on the slope of the Zuid Kapp Trench (Sørkapp or Torellneset) (St. 2054, 334 m and St.

3296, 280 m) can one notice a sharp change in the mechanical composition of sediments along the vertical, as well as the effect of the bottom relief on the composition of the underlying layer: mud at St. 3496 and clay-like mud at St. 2054.

In comparison with the neighboring areas, with the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoye melkovod'ye), for instance, the thickness of sediments lying between individual boundary surfaces has increased somewhat and the curve is rather extended. This can be readily explained by the nearness to the source from which the material is coming. On the western underwater slope of Spitsbergen, in an area characterized by active action of the Atlantic Current, the sediments contain a considerable amount of microfauna. This was disclosed by M. A. Batalina's analyses (see page 266) and is confirmed by N. A. Voloshinova's findings. The last station on the western slope of Spitsbergen (2050) representing a mixed core indicates the presence of the following forms: Lagena sp. sp. — usually; Globigerina; Nonion umbilicatulum Montagu, var., pacifica Cushman — usually; N. labradoricum (Dawson) — 1; Astrononion stellata (Cushman et Edwards) — 1; Elphidium incertum (Williamson), var. clavatum Cushman — seldom; E. arcticum (Parker et Jones) — seldom; Angulogerina angulosa (Williamson) — 3; Cassidulina crassa Orb. — seldom; Cass. nocrossi Cushman — seldom; Cassid. laevigata Orb., var. carinata Cushman — usually; Miliolina sp. — 1; Eponides karsteni (Reuss) — many; Cibicides refulgens Montf. — very many; Cibicides sp. — very many.

A poorer fauna was observed by N. A. Voloshinova in the Zuid Kapp Trench (Sørkapp or Torellneset) in examining the lower layers of cores ranging from 20 to 24 cm (at St. 3296). Here in the pinkish-gray mud the following organisms were found: Nonion labradoricum (Dawson) — 1; Elphidium incertum (Williamson), var. clavatum Cushman — many; Elphidium /325 sp. — seldom; Eponides sp. — by single specimens; Cassidulina crassa Orb. — many; Cassid. laevigata Orb., var. carinata Cushman — seldom; Cibicides refulgens Montf. — 3; Cibicides sp. — seldom.

16. The Polar Basin Slope

For the characterization of sediment stratification on the Polar Basin Slope, 41 cores ranging from 11 to 122 cm were utilized. Most of the cores did not penetrate the Recent sediment layer. The boundary surfaces are usually represented by ferrous interlayers with accumulations of ocherous spots and they are confined to the following depth levels: from 6 to 7, 15 to 17 and 20 to 22 cm (fig. 135). Abrupt changes in the composition of sediments are observed on slopes (Stations 2851, K493, K499, K788, K789 and K799). To the north of Franz Josef Land the cores reflect processes of accumulation, and they do not penetrate the Recent sediment layer. In the submarine valley lying between the Bolshoi (ostrov Bolshoy Lyakhovskiy) and Bely or White (ostrov Belyy) Islands, the entire core represented the in situ eroded material — namely: those of the rosy-colored marl (St. K499).

The curve representing the frequency of occurrence for the Polar Basin Slope has a somewhat different character, which is partly reminiscent of the same curve for the northern shoal of Novaya Zemlya (fig. 136). The most frequently occurring boundary surfaces are found at a depth of 3 cm (which is basically a replacement of the pink layer with the greenish-gray or gray layer); at a depth of 7 cm, 10 cm and deeper — at 17 and 25 cm — the boundary surfaces are not so clearly pronounced. Sharp changes in the mechanical composition of sediments along the vertical are noticeable in the northernmost part at approaches to the Arctic Basin Slope (Stations K790, 204 m; K793, 344 m; K799, 250 m; K122/16, 289 m; K493, 286 m and others). The underlying layer of all of the cores is represented mainly by mud with a two-apex graph of mechanical composition, which is very similar for cores at various stations. This attests to a similar hydrodynamical regime during the sedimentation process of the underlying layers and can be explained by the nearness of the rim of the continental shelf of the Arctic Basin. As in the previously mentioned areas, the amplitude of fluctuation in the mechanical composition during the sedimentation of the underlying layer was less than at the present time. At great depths, here (St. 2834, 1700 m), as in the Greenland Sea, a certain increase in the size of material is observed at the bottom of cores. It is weakly pronounced near the Nansen Ridge (St. C37, 975 m; St. 2384, 483 m), and also at St. K122/18 (230 m) on the slope of the underwater valley of Franz-Viktoriya Trench. To the north of Franz Josef land, the surface layer of sediments (St. K794) contains a small quantity

of Foraminifera shell fragments, spines of sponges, (and) radiolaria fragments, which have evidently been brought by the Atlantic Current. Between 30 and 33-cm of the cores at St. K788 N. A. Voloshinova identified the following organisms: Nonion labradoricum (Dawson) — 2; Elphidium sp. indet. — 2; Cibicides refulgens Montf. — 1.

17. The Northern Plateau
(Severnoye Plato)

As a consequence of retarded sedimentation, the thickness of the modern sediments blanketing the vast area of the Northern Plateau is insignificant, which leads to the appearance of ancient sediments in the lower section of cores. A maximum thickness (fig. 101) was noted in a deep depression merging with the Franz-Viktoriya Trench, but here also the thickness of the Recent sediment layer does not exceed 30 cm for a considerable area. The upper layer of the cores which had been taken from the submarine bank and slopes of elevations in areas where the water movement is fast is marked by a negligible thickness of Recent sediments, and is represented by sandy mud, but the bottom section of the cores contains gray and rosy-gray, sometimes bluish-gray sediments which are frequently enriched with gravel and shingle, especially at boundary surfaces (Stations 1035, 253 m; 1248, 240 m; 2894, 236 m; K814, 252 m; K912, 193 and others).

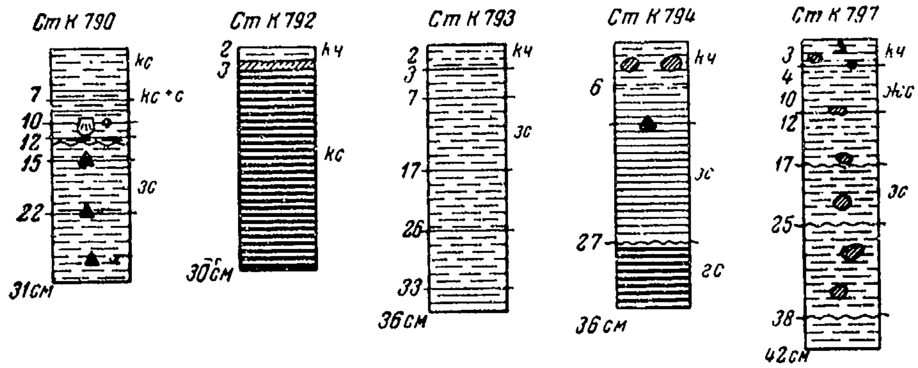

Fig. 135. Boundary surfaces on the submarine slope of the Polar Basin. Cores from stations: K790, 204 m; K792, 520 m; K793, 344 m; K794, 231 m; K797, 281 m. Symbols explained in fig. 46.

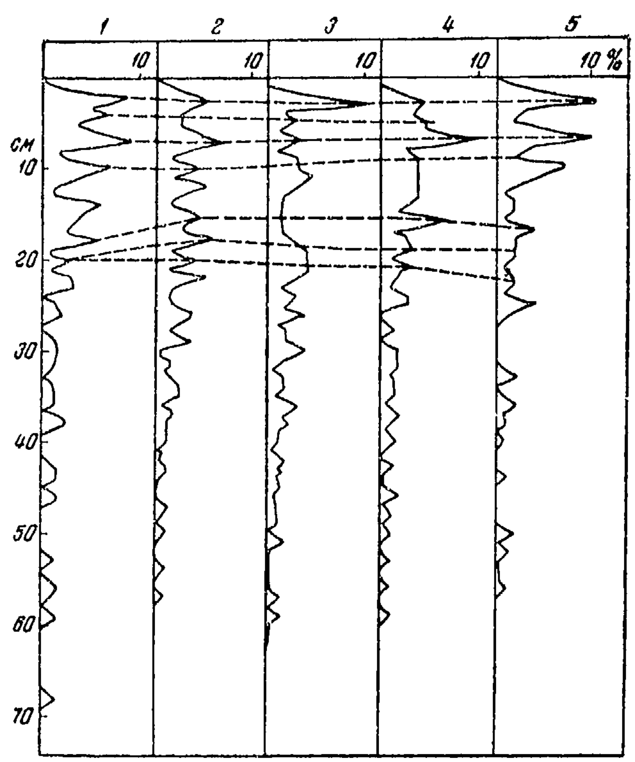

Fig. 136. Curve of frequency occurrences at boundary surfaces in cores by areas.

1--the northern shoal of Novaya Zemlya; 2--the Central Depression; 3--the Northeast (Nordaust) Depression; 4--the Polar Basin Bay; 5--the slope of the Polar Basin.

In the latter cores between the overlying Recent sediment, pink-colored in the upper layer and greenish- and bluish-gray in a lower layer, and the underlying layer consisting of a rosy-gray mud or clay-like mud one finds interstratification of a greenish-gray sandy mud containing gravel and carbonate remains with a rosy-gray, more clayey mud. The shingle and gravel found on the boundary surfaces testifies to a sharp change in conditions, as well as to erosion that had occurred after the deposition of the rosy-gray sediments.

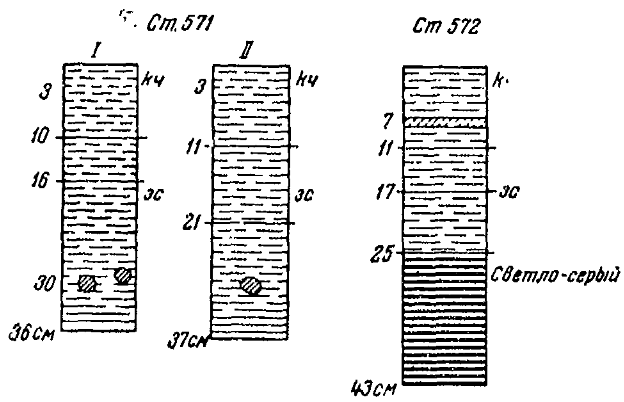

Fig. 137. Rhythmicality of sediments in the Northern Plateau area (St. 571, 261 m; St. 572, 315 m). Symbols are explained in fig. 46.

Key. Horizontal line to the right of figure: light-gray

A number of cores in the Northern Plateau are marked by well pronounced strata of the ancient ferrous weathering, for instance, at St. 1429, at a depth of 25 to 27 cm. We are inclined to consider these layers as belonging to the eras characterized by an inhibited sedimentation,

sometimes by no sedimentation and intensification of water circulation, but not by intensified impact of the Atlantic Current as is assumed by M. M. Ermolaev.

In accumulation areas the character of stratification is different: here we have a well pronounced boundary between the pink oxidized upper layer and the greenish- and bluish-gray lower layer which sometimes has a coffee-brown hue. At the boundary one can frequently notice stratification — alternation of layers which are more or less colored by brown oxides. A variation in mechanical composition occurs gradually, and the mud composing the upper sections of cores grades into clay-like mud, as we go deeper into the bottom. As in the case of other areas in the Barents Sea, here we note permanent boundary layers which usually extend along the clay patches that form natural cleavages, i.e. the rhythmicality observed in the southern part of the Barents Sea also occurs here (fig. 237). Most frequently the boundary layers occur at sediment depths of 6,9, 11, 13, 18, 20 and 25 cm, but in longer cores at 30 to 31, 35, 38, 40 to 41, 44 cm and so on.

In washout areas the cores exhibit consolidation of sediments in the lower layers, for instance near the Persey Bank on the slope of the Franz-Viktoriya Trench (St. 1967, 317 m), in the central section of the Northern Plateau (Severnoye Plato) (St. 1037, 275 m), on the southern slope of the Persey Bank (St. 1258, 187 m), on the underwater slope near the White or Belyi (ostrov Belyy) Island (St. K501, 229 m), to the south of the island (K775, 249 m) and at other points.

In line with considerable differences in the lithologic composition of the upper and lower sediment layers in the Northern Plateau, it is thought that the erosion products of the rocks occurring in situ, which are found in the lower layers of cores, contain specimens of the ancient microfauna. A number of samples was given to N. A. Voloshinova for ex- /328 amination. She found that near the King Karl Island (Kong Karl Land or Kong Karls Land or Kongsøya) (at St. M75, 292 m) the section of cores from 40 to 43 cm contained Cibicides refulgens Montf. — by single species.

Between the Persey Elevation and the White or Belyi Island (ostrov Belyy) (St. M99, 250 m) the sandy interlayer with gravel and carbonate remains at 25 to 27-cm marks of cores contained the following organisms: Nonion umbilicatulum Montagu, var. pacifica Cushman — single specimens; N. incertum (Williamson), var. clavatum Cushman — single specimens; N. labradoricum (Dewson [sic!]) — single specimens; Nonion sp. and Globigerina — single specimens; Cassidulina crassa Orb. — single specimens; Cass. laevigata Orb., var. carinata Cushman — usually; Cass. norcrossi Cushman — 1; Cristellaria sp. — 1; Eponides sp. — single specimens; Cibicides refulgens Montf. — single specimens; Cibicides sp. — 1, i.e. a rich foraminifera fauna; however, according to N. A. Voloshinova, not older than Quaternary period. At 38 to 40-cm in the same core, a mixture of gray and yellowish mud, which had a lumpy structure, was very dense, effervesces when treated with acids, and was reminiscent of washouts of rocks occurring in their place of origin, contained the following organisms: Globigerina; Elphidium incertum (Williamson), var. clavatum

Cushman — seldom; Nonion sp. — 2; Non. umbilicatulum Montf. — 1; Pullenia bulloides Orb. — 1; Cassidulina crassa Orb. — usually; Cassid. laevigata Orb., var. carinata Cushman — many; Cibicides refulgens Montf. — usually.

A little to the north about 30 miles to the south of the White or Belyi Island (ostrov Belyy) (St. M101, 350 m) the lower layer of gray clay, which was dense and heavy and had a somewhat lumpy structure containing admixture of gravel formed of dark sandstone and other rocks, included the following organisms at the depth ranging from 35 to 37 cm: Globigerina; Nonion umbilicatulum Montagu, var. pacifica Cushman — 3; Nonion sp. — seldom; Elphidium arcticum (Parker et Jones) — 1; Elphidium sp. — 1; Elph. incertum (Williamson), var. clavatum Cushman — usually; Cassidulina crassa Orb. — many; Cass. laevigata Orb., var. carinata Cushman — usually; Cass. norcrossi Cushman — seldom; Miliolina sp. indet. — 1; Bulimina sp. — 1; Eponides sp. — 4; Cristellaria sp. — 1; Cibicides refulgens Montf. — usually; Cibicides sp. — seldom.

To the west of the King Karl Islands (Kong Karl Land or Kong Karls Land or Kongsøya) (St. M110, 100 m) the gray sandy mud replete with broken fragments and gravel of gray schist and representing washouts of the rocks occurring in their place of origin (containing only small patches of sand from the surface layer which has been formed during the modern era) contain the following organisms in the layer ranging from 5 to 11 cm of cores: Globigerina; Lagena marginata (Walker et Jacob) — 1; Elphidium incertum (Williamson), var. clavatum Cushman — by single specimens;

Nonion umbilicatulum Montagu, var. pacifica Cushman — 1; Miliolina sp. Orb., var. carinata Cushman — many; Cass. nocrossi Cushman — seldom; Eponides sp. — 1; Cibicides refulgens Montf. — many; Cibicides sp. — usually; sandy rhizopods — 2.

Between the shoal of the King Karl Islands (Kong Karl Land or Kong Karls Land or Kongsøya) and the Persey Elevation (St. M111, 273 m) an interlayer with microfauna, which lies beneath the pink mud of the upper layer on a rough surface of the underlying sediments, contains: Cibicides refulgens Montf. — 5; Cibicides sp. — seldom; but the dark gray mud at depth level ranging from 33 to 37 cm is characterized by a somewhat richer microfauna: Cassidulina crassa Orb. — 1; Cass. laevigata Orb., var. carinata Cushman — 1; Elphidium sp. indet. — 1; Globigerina sp. — 1; Cibicides refulgens Montf. — 2.

On the western slope of the Persey Elevation (St. M117, 240 m) the bluish-gray sandy clay with shingles of semi-decomposed feldspar sandstone with carbonaceous interstrata, Cristellaria sp. — 1 and fragments of microfauna were observed at 31 to 37-cm marks of cores; the pinkish-gray sandstone in the bottom of the core at the 50-cm mark contained: Globigerina; Elphidium incertum (Williamson), var. clavatum Cushman — 1; Elph. incertum Williamson — seldom; Nonion sp. — 3; Eponides karsteni /329 (Reuss) — 1; Eponides sp. — 4; Cassidulina crassa Orb. — by single specimens; Cass. nocrossi Cushman — 1; Cibicides refulgens Montf. — 2; Cibicides sp. — 2.

At 3 to 5-cm marks of a core taken from the slope of the Polar Basin Bay in the eastern part of the Northern Plateau (St. 1946, 176 m) the pink mud contained Cibicides sp. indet. — 1. At 14 to 18-cm in the cores the dense, dark-gray, irregularly stratified mud contained sandy rhizopods which were not well preserved — 2; Nonion umbilicatulum Montagu, var. pacifica Cushman — 1; Cibicides refulgens Montf. — 2; Cibicides sp. — 3.

The dark greenish-gray mud verging on sandy mud and lying between 27 and 44-cm in a core and replete with remains of microfauna in a very enriched layer between 34 and 37-cm marks contained the following organisms: Lagena sp. sp. — 5; Astrononion stellatum Cushman et Edwards — 5; Nonion umbilicatulum Montagu, var. pacifica Cushman — usually; Elphidium arcticum (Parker et Jones) — many; Elph. incertum (Williamson), var. clavatum Cushman — seldom; Elphidium sp. — usually; Cassidulina crassa Orb. — many; Cass. nocrossi Cushman — many; Cristellaria sp. — 2; Miliolina sp., sp. — 6; Cibicides refulgens Montf. — many; Cibicides sp., sp. — many; Ostracoda — seldom; Globigerina; among them Cassidulina crassa — in a great quantity. Lastly, the sandy mud layer in the bottom of the core between 45 and 51-cm, which was reminiscent of the surface layer but differed from it by a well pronounced stratification, was characterized by alternation of gray and pink strata containing sandy rhizopods, single Cibicides refulgens Montf. and few Cibicides sp. (N. A. Voloshinova).

A core at St. 2885 at the foothill of the slope of Franz-Viktoriya Trench includes light-gray clay-like mud in the gray mud, the former having interstrata and pockets (fig. 138). A sediment layer with a similar mechanical composition can be observed at 28-cm in a core obtained 7 miles to the south (St. 2884). The lower sections of cores (see page 192) obtained from the slope of the Persey Bank contain stratified layers reminiscent of river sediments. When analyzing a core obtained at St. 2889, it can be seen that a well cemented mud alternates with muddy sand.

18. The Western (Medvezhinskiy) Trench

In order to characterize the sediment stratification in the Western Trench, 52 cores from 11 to 132 cm long were utilized. In the western part of the trench there is an area characterized by a retarded accumulation in which the recent layer 10 to 20 cm thick is underlain by layers of different types. In contrast to the areas described earlier, the transition from the recent layers to the older layers does not contain traces of erosion and is only seldom accompanied by interstratification, increase in the size of the material and similar phenomena associated with a sharp variation of conditions (Stations 1881, 475 m; 2150, 428 m; 2369, 448 m; 2791, 492 m; 655, 296 m and others; fig. 139). The boundary surfaces are usually confined to 2, 5, 7, 10, 12, 15, 17, 22, 25, 27-cm and other layers which in the upper section of cores are moved closer together in comparison to the neighboring areas -- namely, the Western Commercial Banks and the Bear-Spitsbergen Shoal (Medvezhinsko-Spitsbergenskoya melkovod'ye).

On the whole, the frequency of boundary surfaces indicates a retarded rate of sedimentation and it is evident that here the cores embrace a considerably longer time period than in other areas. The great length of the collected cores is associated with the fact that here also the ancient layers pertain to the noncondensed marine layers. Even the usual cores penetrate the bottom here considerably deeper than on the elevation.

Evidencing the stability of conditions through time, the variation of mechanical composition by cores is not sharp. Even at places where the underlying layers are reached, the noticeable variation in the mechanical composition — namely, the transition from mud to clay-like mud, or from sandy mud to mud, occurs gradually.

/330

A sample taken at St. 1143, 470 m, was subjected to microfaunal analysis. A greenish-gray sandy mud layer lying between 4 and 7-cm marks of a core, examined by N. A. Voloshinova, appeared to have: Nonion umbilicatulum Montagu, var. pacifica Cushman — by single specimens; Elphidium incertum (Williamson), var. clavatum Cushman — by single specimens; Lagena marginata (?) (Walker et Jacob) — 1; Pullenia bulloides Orb., — 1; Globigerina; Cassidulina laevigata Orb., var. carinata Cushman — usually; Cass. crassa Orb. — seldom; Cass. nocrossi Cushman — seldom; Cibicides refulgens Montf. — seldom; Cibicides sp. — seldom; Angulogerina sp. indet. — 1, but a rosy-gray more fine-grained mud — a transition to which in the core was very gradual — contained the following organisms in the layer ranging from 45 to 47 cm: Nonion umbilicatulum Montagu, var.

pacifica Cushman — seldom; Cassidulina crassa Orb. — seldom; Cass. laevigata Orb., var. carinata Cushman — by single specimens; Globigerina; Cibicides refulgens Montf. — by single specimens; Eponides sp. — by single specimens.

Fig. 138. Landsliding of sediments on the slope of Franz-Viktoriya Trench (St. 2885, 333 m; from 24 to 52 cm of the core).

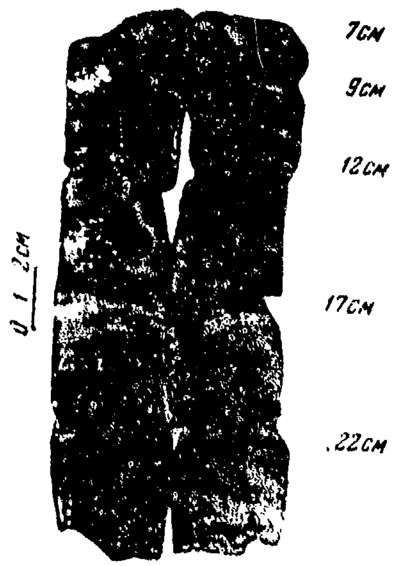

Fig. 139. Stratification and rhythm in the Western (Medvezhinskiy) Trench (St. 655, 296 m; from 7 to 24 cm of the core).

Of greatest interest is the distribution of Cassidulina laevigata which, according to the investigations by V. P. Androsova (1935), is most frequently found in the sediments of the Barents Sea at temperatures ranging from +3 to +1.5°C and at salinities ranging from 33.9 to 35.2 °/oo, i.e. it is confined to more saline and warmer waters than Cassidulina crassa and Nonionina depressula.

Thus the scarcity of this organism in the lower sediment layers indicates that the sedimentation had occurred at lower temperatures and salinities, i.e. in other climatic conditions. The use of the quantitative method of microfaunal analysis in the future will evidently help determine more definitely the age of the underlying layers of sediments on the Western (Medvezhinskiy) Trench.

At 14 to 16-cm in the core (St. 1141), the gray mud enriched in rhizopods contained a similar composition of fauna, however the admixture of Atlantic forms was slightly greater; Elphidium incertum (Williamson), var. clavatum Cushman — seldom; Nonion umbilicatulum Montagu, var. pacifica Cushman — usually; Pullenia bulloides Orb. — 2; Cassidulina laevigata Orb. var. carinata Cushman — 2; Bulimina sp. — 1; Globigerina sp.; Cibicides sp. — seldom; Cibicides refulgens Montf. — seldom. /331

A considerably poorer fauna was found by N. A. Voloshinova in a rosy-gray sandy mud (at 23 to 24-cm, St. 1157, 410 m) near the southeastern slope of the Bear-Spitsbergen Bank (Medvezhinsko-Spitsbergenskaya banka). Here she identified the following species: Eponides karsteni (Reuss) — by single specimens; Cibicides refulgens Montf. — seldom; Cibicides sp. — seldom; Globigerina sp. — 1.

At a smaller depth (St. 1936a, 280 m) the bluish-gray layer with a slight rosy-colored hue, consisting of a dense and heavy sandy clay replete with gravel, shingle and fragments of shells, contained the following species at 15 to 18-cm (according to N. A. Voloshinova): Trochammina (?) sp. — 1; Lagena sp. 1 — 1; Lagena sp. 2 — 1; Nonion labradoricum (Dawson) —

by single specimens; Non. umbilicatulum Montagu, var. pacifica Cushman — by single specimens; Astrononion stellatum Cushman et Edwards — 1; Elphidium incertum (Williamson), var. clavatum Cushman — usually; Elphidium incertum (Williamson) — 1; Elphidium sp. 1 — 2; Glodigerina sp. 1 — 2; Globigerina sp. 2 — 3; Angulogerina angulosa (Williamson) — 2; Cassidulina crassa Orb. — very many; Cass. nocrossi Cushman — seldom; Cass. laevigata Orb., var. carinata Cushman — very many; Miliolina sp. sp. — 7; Cibicides refulgens Montf. — seldom; Cibicides sp. sp. — many; Eponides sp. indet — by single specimens, i.e. a very rich fauna of a mixed type. This is completely understandable because of the location of the station in an area where the warm and cold waters as well as rapid currents join each other.

19. The Central Depression

(Tsentral'naya Vpadina)

The major part of cores (54 cores from 12 to 90 cm long) have not penetrated the modern sediments in the Central Depression. Older sediments can be observed only along the edges of the depression: on the eastern slope of the Central Elevation (St. 2473, 282 m), on shoaling ridges (Stations 2476, 269 m; 2481, 346 m; 2482, 350 m; 759, 304 m and others), as well as on the southern slope of the depression - namely, in the area characterized by active impact of a strong branch of the Nordkapp Current on the slope (Stations 1079, 266 m; 632, 335 m; 757, 306 m and others). The southern part of the depression is marked by a well pronounced transition layer in the form of a clay-like, and usually rosy-

gray, sediment mixed with a more sandy greenish-gray sediment, as well as with older weathered sediments (fig. 140).

The major part of the cores penetrating the modern sediments contain features that are typical of accumulation areas. The boundary surfaces are well pronounced in them; sometimes they contain patches of sand which follow one another closely (for instance, at St. 768, 306 m, near the eastern edge of the depression; fig. 140). The more stable boundary surfaces were clearly manifest on the curve of frequency occurrence (fig. 136) at 3, 7, 10, 12, 15, 18, 20, 22, 26 and 28-cm marks. The number of measurements for deeper strata was very small.

Vertical changes in the mechanical composition of the sediments, which were detected earlier (Ia. V. Samoilov and M. V. Klenova, 1927), are also confirmed by later observations. The underlying layers have a different mechanical composition (more fine-grained), but at the bottom of the surface layer one can sometimes notice an increase in the size of material (St. 765). N. A. Voloshinova, examining a layer lying near a relatively shallow bank between the northern and southern sections of the depression (St. 764, 304 m) found that it consists of a mud having a slightly rose-colored hue between 15 and 34-cm marks. The upper layer consisting of a greenish-gray sandy mud contained the following species at 6 to 8-cm /332
marks: Haplophragmoides sp. — by single specimens; Nonion umbilicatulum Montagu, var. pacifica Cushman — by single specimens; Cassidulina crassa Orb. — by single specimens; Cassidulina laevigata Orb., var. carinata Cushman — by single specimens; Cibicides refulgens Montf. — 1; Pullenia

bulloides Orb., whereas the gray clay of the lower layer (from 17 to 22 cm) contained only sandy rhizopods badly preserved — Cibicides sp. Between 9 and 14-cm marks of the core, she disclosed a well pronounced transitional layer with ocherous inclusions and gravel consisting of smooth grains.

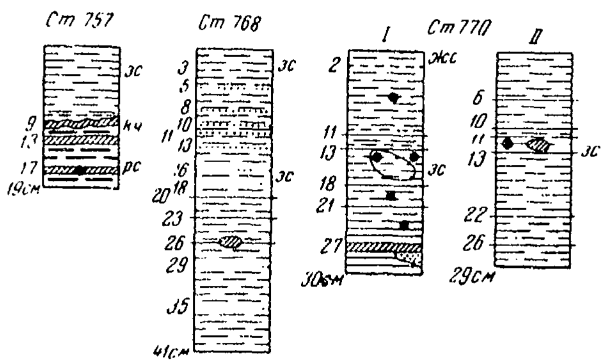

Fig. 140. Stratification in the Central Depression — St. 757, 306 m; St. 768, 306 m; St. 770, 245 m. Symbols are explained in fig. 46.

20. The Northeast (Nordaust) Depression

(Severo-Vostochnaya Vpadina)

In the Northeast Depression, as in other deep areas, deposition prevails. Altogether 28 cores from 15 to 64 cm long were utilized. Uniform cores were obtained from the greatest depths; their vertical composition changes gradually. They have well pronounced boundaries in the form of clay patches and — less frequently — sand patches, as in the case of other accumulation areas. However, the boundaries are somewhat displaced

toward the surface, which attests to a considerably retarded sedimentation. A well pronounced boundary layer in the form of ocherous spots and ferrous interlayers was observed at the 5 cm depth, less frequently at the 7 cm depth; the layer laying at 2 and 3 cm depths appears mainly to be a transitional layer between the pink and pinkish-gray upper layer and the greenish-gray, less frequently bluish-gray, lower layer.

The cores obtained from shallower areas or from places nearer to the slope of the northern shoal of Novaya Zemlya disclose the characteristics of interrupted and undisturbed sedimentation, interstratification of sediments having a different color (fig. 141), accumulation of brown oxides, interlayers of gravel (Stations 2696, 261 m; 2698, 365 m; 1979, 317 m and others). These features are already known to us. The deeper segments of a number of cores disclose ferrous interlayers that characterize the surface of ancient weathering (fig. 141), which sometimes is twice repeated (for instance, at St. 1977, 313 m — between 7 and 10 cm and between 39 and 46 cm).

Changes in the mechanical composition more often than not indicate increase in the size of material toward the bottom, which is sometimes gradual, sometimes abrupt (fig. 141). The lower layers (Stations 2697, 2698, 2700, 2982 and so on) are represented by sandy mud which is well assorted, whereas the upper sections of cores are represented by a mud reminiscent of a clay-like mud.

At maximum depths the cores had not penetrated the modern sediment which in the upper layers is represented by mud but in the lower layers by clay-like mud (St. 2701, 340 m; St. 2709, 339 m). The lower section of a core taken at St. 2704, 329 m, was characterized by micro-strata — an alternation of a more sandy and more muddy sediment.

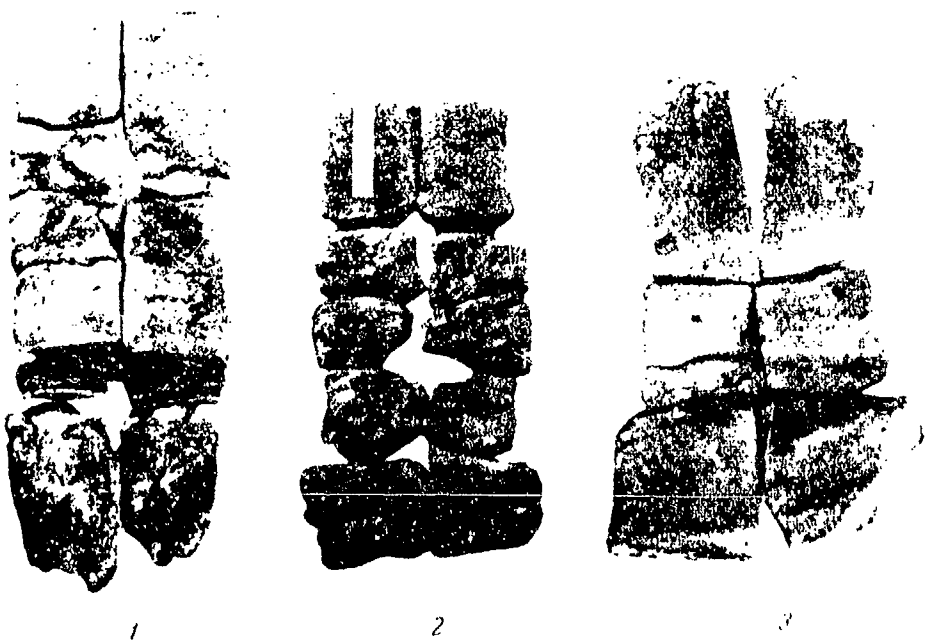

Fig. 141. Stratification of sediments in the Northeast (Nordaust) Depression.

1 -- St. 1977, 312 m; from 25 to 46 cm. The surface of ancient weathering — ferrous interlayer at 39 cm; 2 — St. 2702, 325 m; from 26 to 40 cm. Transitional layer — a mixture of gray and pinkish-gray sandy mud at 30 to 34 cm; 3 — St. 2700, 346 m; from 30 to 42 cm. Abrupt change in the mechanical composition of sediments and a change in the median diameter at 37 cm in the boundary between the greenish-gray mud and the dark gray sandy mud.

A microfaunal analysis (N. A. Voloshinova) in the shallower section of the area (St. 1973, 214 m) disclosed the presence of the following forms between 2 and 5-cm marks of cores in the gray sandy mud: Elphidium incertum (Williamson), var. clavatum Cushman — 1; Globigerina — 1; Cassidulina nocrossi Cushman — single specimens; Cibicides refulgens Montf. — 2; Cibicides sp. — 2; but at greater depths in a gray sandy mud whose uneven surface is covered by the upper layer the following species were disclosed between 29 and 31-cm: Cassidulina crassa Orb. — 1; Cassid. sp. indet. — 2; Cibicides refulgens Montf. — single specimens; Cibicides sp. — seldom.

21. The Polar Basin Bay

(Bukhta Polyarnogo Basseina)

The sediment stratification of the Polar Basin Bay, which forms an intermediate area between the Barents and Kara Seas and the Arctic Basin proper, is extremely peculiar. 33 sample cores ranging from 11 to 65 cm have been utilized to characterize the area.

The frequency of occurrence curve for the Polar Basin Bay (Fig. 136) is similar to the curve characterizing the Polar Basin Slope. The most frequently occurring boundary surfaces are confined to the 3 and 7-cm /334 depth levels, less clearly to the 11, 16, 19 and 21-cm depth levels. The upper layers coincide by areas, but the lower layers of the cores are characterized by the fact that the greatest magnitudes of frequency of occurrence in the Polar Basin Slope are more separated in comparison with the bay, which is evidently due to a greater speed of sedimentation on

the slope.

The most typical feature of stratification in the cores is the ferrous interlayers, which are frequently consolidated and form nodes when dry. According to M. M. Ermolaev (1948), who investigated the cores obtained to the north of the area, the ferrous interlayers are associated with a periodic and more intense inflow of the Atlantic water.

Because the ferrous interlayers occurring in the entire expanse of the Barents Sea are mainly confined to washout areas or ancient weathered layers caused by a retarded sedimentation, it seems to us that M. M. Ermolaev's hypothesis requires a closer examination. One of the best examples of such stratification is a core taken at St. 1266, 290 m (fig. 99) where the ferrous interlayers are found from 13 to 14, 29 to 30 and 56 to 65-cm depth levels of the pink sediments.

In a core taken at St. 1960, 389 m, at a distance of 15 miles to the south of St. 1266 and on the slope of the Northeast (Nordaust) Bank, the same ferrous interlayers lie nearer to the bottom surface -- at 5 cm, 19 cm and 35 to 37 cm. At the latter depth level one can find interlayers containing rich ferrous formations with gravel between which a layer (approximately 1 cm thick) of gray clay-like material with an ocherous band lies at a distance of 1 mm from the upper surface. Thus here we have a representative layer of ancient weathering.

In the greater part of the cores the lower layer is more fine-grained than the upper layer. The variation in mechanical composition occurs

uniformly from sandy mud to mud and clay-like mud (Stations 1948, K808 and others). Sometimes, as in the case of a core obtained at St. 1950, a sharp change in mechanical composition takes place. The cores obtained at shallower depths and from underwater slopes are characterized by an increase in the size of material in the lower layers (St. K800, 129 m; St. K802, 213 m; St. K812, 193 m and others), as was the case in the Northeast (Nordaust) Depression. Near the slope of the Northern Shoal of Novaya Zemlya, the Recent greenish-gray sandy layer is underlain by a rosy-gray clay-like mud — an erosion of the underlying type of marl. The quantity of particles smaller than 0.01 mm appeared to equal 85.9%. The coarse-grained material in the bottom of the cores is sometimes replaced by a more fine-grained sediment (for instance St. 1948, 195/250 m, on a slope leading to the extreme eastern spur of the Frans-Viktoriya Trench). In the lower layer, the clay-like mud is f und on the slope of a shoal between the Vil'chek Land (zemlya Vil'cheka) and the great depths of the Polar Basin Bay (St. K805, 193 m). N. A. Voloshinova identified the following species in the greenish-gray mud: Nonion sp. indet — 2; Globigerina — 3; Cibicides refulgens Montf. — 1, but in the lowest part of the core filled by a dense and heavy yellowish-gray mud (with a slight greenish hue), which was similar to interlayers found in other cores, no microfauna was found between the 25 and 27-cm levels.

Thus also in the Polar Basin Bay, where as a result of a slow sediment deposition older layers were evidently disclosed in the cores, no microfauna older than the Quaternary was found.

As was established by S. V. Bruevich (1946, 1952), the diffusion of bottom solutions occurs slowly in the cores, and it is possible to observe buried water in a vertical cross-section, whose composition reflects the salinity of waters of the old basin. The cores obtained from the Barents Sea were not studied from this point of view, but the visual examination and tasting of samples disclosed that the lower layers of the gray and bluish-gray sediments were less saline than the upper Recent layers. In /335 connection with it, several analyses were made of the water squeezed out of the upper and lower layers of the cores obtained at 7 stations in the northern portion of the Barents Sea, where a decrease in the salinity of lower layers occurred most frequently. The Cl' and SO_4'' that evolved from the water (A. S. Pakhomova) consisted of 0.53 to 1.49% of Cl' and 0.86 to 2.01% of SO_4'' for the upper layers of varied mechanical composition (Stations K790 on the Polar Basin Slope, 1246 and K775 on the Northern Plateau). In the lower layers of cores having the usual salinity /Stations K790 on the Polar Basin Slope and 1017 in the northern portion of the Bear (Medvezhinskiy) Trench at 10 and 20 cm, Stations 2694 and 1246 on the Northern Plateau/ the quantity of Cl' fluctuated from 0.44 to 1.04%, but the quantity of SO_4'' from 0.91 to 1.87%. For the mud from the lower layers of the cores, which was marked by a decreased salinity (not saline at taste), and obtained at Stations 1948 in the Polar Basin Bay (34 cm), K775 (15 and 30 cm) and 1248 (20 cm) in the Northern Plateau, the content of Cl was expressed as follows: 0.64; 0.67; 0.39 and 0.64%, but the content of SO_4'' 1.78; 1.57; 1.63 and 1.66%, respectively.

Thus it was impossible to establish a specific rule. The ratio of the sulfuric acid ion to chlorine disclosed a definite pattern of change only with respect to St. K775. Here in the upper layer of pinkish-gray clay it equaled 1.36, at the 15-cm mark of the core in a light-gray mud it equaled 2.34, and at the 30-cm mark in a dense rosy-gray clay it was 4.18, i.e. it reflected, as in the case of chlorine, a considerable dilution of the basin during the deposition of the lower sediments. The investigation of changes in salinity of the buried waters of ancient basins in the Barents Sea, and generally in the northern seas, is a problem of the future.

On the charts indicating the mechanical composition (fig. 142) of the underlying layers of cores, we have marked the data pertaining only to areas characterized by thin layers of Recent sediments, i.e. to areas where the Recent sediment is divided by a sharp boundary from the older layers. It can be seen that during the deposition of the old layers, which we cannot determine because of the absence of data as to the absolute age, certain relief elements had already existed in the Barents Sea, but they evidently had a rather milder character. Thus, for instance, on the Central Elevation, the variation in the mechanical composition of the sediments indicates a transition from elevated areas to the Central Depression on the north and to the underwater gulf on the south, but the mechanical composition fluctuated in a considerably smaller range than at the present time. At the present time muddy sand is being deposited on the slopes of the Central Elevation; at great depths the muddy sand is replaced by sandy mud or mud; but no material coarser than sandy mud was

found in the underlying layers.

The mechanical composition of sediments on the underwater slope of the Bear-Spitsbergen Bank (Medvezhinsko-Spitsbergenskaya banka) is replaced in the same way. At great depths, where at the present time muddy sand or sandy mud verging on the former is being deposited, the underlying layers contain mud which is, for the most part, fined-grained verging on clay-like mud, sometimes actually clay-like mud. A sharp replacement of muddy sand with sandy mud, and mud with clay-like mud, as we noticed above, mostly in connection with the erosion layers, was disclosed in the southern part of the sea — on the Murman Bank, Murman Shoal and on the Central Plateau. In a milder form, this is repeated along the cross section Cape Nordkapp-Bear Island (Bjørnøya) where the clay-like mud was not found in the lower layers. A very distinct stratification is observed in the souther.. portion of the Central Depression (St. 1078) and partly on the Novaya Zemlya Shoal.

The mere mention of the areas shows that they are confined primarily to the streams of the most potent currents. It is evident that the penetration of Atlantic waters results in the appearance of a sharp boundary line between the upper and lower layers, the former of which is, for the most part, greenish-gray or yellowish-gray and more coarse grained, and /336
the latter either gray or rosy-gray or bluish-gray.

Changes in the mechanical composition occur in a set pattern in the area of the Northern Plateau. At places where the most fined-grained material is deposited at the present time, the underlying layers of cores contain

a more coarse-grained material — the variation occurring sometimes with interruptions, at other times with gradual transitions. This indicates also a recent change in the hydrological regime which is evidently connected with the formation of the present bottom relief in the northern portion of the Barents Sea, which involves the sagging of the Western Depression of the Arctic Basin.

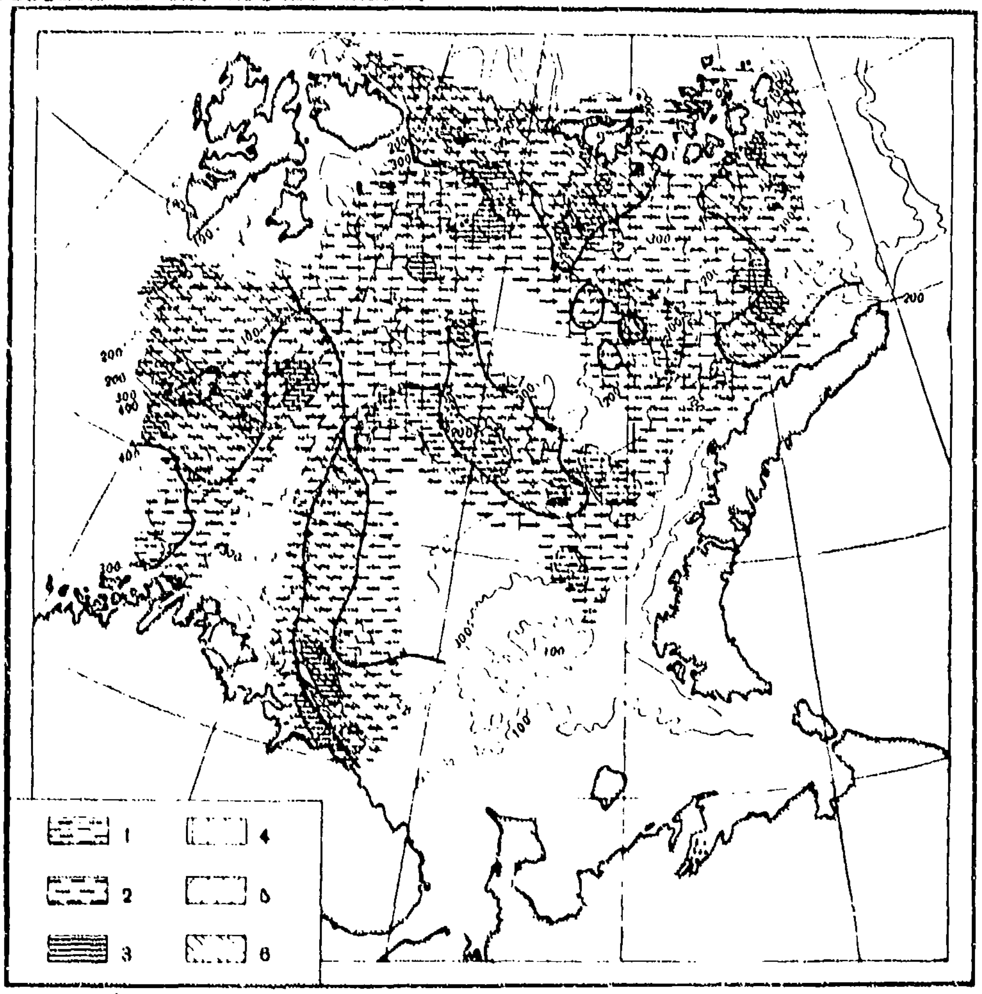

Fig. 142. Mechanical composition of the underlying sediment layer in the Barents Sea.

1--sandy mud (10 to 30%); 2--mud (30 to 50%); 3--clay-like mud (more than 50% of particles smaller than 0.01 mm); 4--gray; 5--bluish-gray; 6--rosy-and pinkish-gray.

The greater part of boundary surfaces in the cores taken from the Barents Sea is associated with changes in hydrological regime, which causes interruptions in sedimentation. Such is the basic boundary between the Recent greenish-gray sediment and the ancient gray sediments having various shades of colors, in which changes in sedimentation are accompanied by erosion phenomena — i.e. by accumulation of coarse-grained sediments, formation of a transitional layer, etc. Sometimes the gaps in sedimentation or the retardation of the rate of sedimentation is manifest by /337
enrichment of the surface layer with sesquioxides which are preserved in cores in the form of ancient weathered layers (fig. 143).

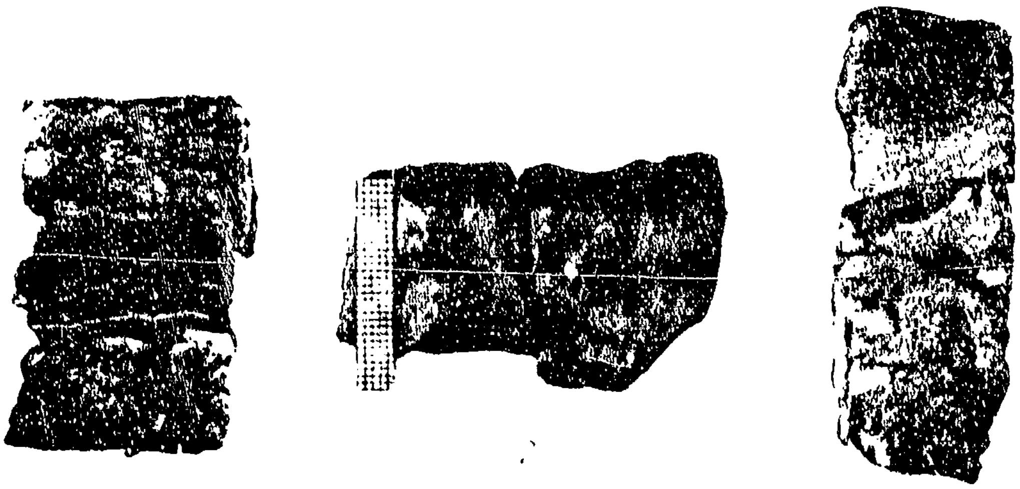

Fig. 143. Ancient weathered layers.

1--St. 1977, 312 m. Increase in the density of a ferrous interlayer at the 39-cm mark of core in the Northeast (Nordaust) Depression; 2--St. 3310, 400 m; 26-cm of core. An ancient weathered layer on the surface of a bluish gray clay in the Bear (Medvezhinskiy) Trench; 3--St. 2699, 432 m. Gradual enrichment of the sediment with sesquioxides without gaps in sedimentation in the Northeast (Nordaust) Depression.

It is more difficult to explain the development of sand patches and spots in the greenish-gray Recent layers. As we learned above, they are characterized by a wide distribution and stability of layers along the vertical, especially in the cores taken from locations lying relatively near to one another. In such instances the sand patches and spots, along which cleavages occur when in a dry condition, usually coincide with an accuracy of one cm, and their alternation in a cross section creates a definite rhythm. It is evident that they reflect certain phenomena marking the activation of the hydrological regime over the entire expanse of the sea, or, in any case, over vast regions of it. Because the interlayers are especially well pronounced in the southern part of the sea, they evidently cannot be associated with the ice regime. In addition, it can be pointed out that in the cores taken from areas far off the coast the cleavages do not occur along sand patches but along clay spots.

Often the rhythm at high latitudes is expressed by the structure of ice cover (for instance, Viktoriya Islands [ostrov Viktoriya]); however, in the sedimentation of sand patches the rhythm embraces longer time intervals.

On the basis of a change in the chlorophyll content of cores, V. P. Zenkovich and L. A. Iastrebova (1946) concluded that the rate of sedimentation varies.

On the basis of the concept about the post-glacial age of the bluish-gray sediments [according to G. De-Geer (1910), 8000 years ago] and of the thickness of the layer ranging from 30 to 35 cm, the writers assume that the rate of sedimentation of the Recent deposits is approximately 1 cm in

250 years, i.e. 0.04 mm a year. This agrees well with the computations of the rate of sedimentation for the Polar Basin Bay (M. M. Ermolaev, 1948) and for the Central Arctic (V. N. Saks, N. A. Belov, N. N. Lapina, /338
1955).

The same rate of sedimentation can be calculated, when examining changes in the mechanical composition of cores (M. V. Klenova, 1948). According to computations by A. P. Burdykina, which were based on the weight of particles brought into the sea by rivers, the rate of sedimentation in the southeastern portion of the Barents Sea equals 1.1 cm in 1000 years. Thus the various methods of computing the rate of sedimentation leads to the figures of the same order. Assuming that the mean speed is 0.04 mm per year, the time intervals between the sedimentation of individual sand interlayers in the cores equal 2000 to 2500 years.

The activation of the hydrological regime that is manifest in these interlayers had evidently embraced periods from 2 to 3 decades. During this time deposition of the smaller particles did not take place, but relatively larger sand particles accumulated on the bottom. Ice and wind could hardly be considered as the agents exercising a direct influence on sediment transfer. A more likely agent of transfer is the riding of sand particles by the sea foam (V. P. Zenkovich, 1937). It can be assumed that at times an intensified surf occurred in dry weather, and that the waves eroded the dry coastal sand and transferred it for a considerable distance. Thus the formation of sand interlayers can be associated with a periodic intensification of the circulation of atmosphere. On the other hand, the

increase in the circulation of the atmosphere determined also an intensified water movement in the system of permanent currents. Consequently, these causes acted in harmony, causing gaps in the sedimentation of fine-grained material and the preservation of a more coarse-grained material. The sand interlayers in the cores taken from the Barents Sea can be compared with the sandy shell interlayers found in the sediments of southern seas, for instance, in the Caspian Sea (Kaspiyskoye more) where P. G. Popov (1947) succeeded in associating them with the periodic fall in the sea level, which is also determined by changes in the atmospheric circulation.

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